Pathology Training in Informatics

Evolving to Meet a Growing Need

John H. Sinard, MD, PhD; Suzanne Z. Powell, MD; Donald S. Karcher, MD

• ***Context.***—**The mechanics of the practice of medicine in general and of pathology in particular is evolving rapidly with the rise in the use of electronic information systems for managing the care of individual patients, including the ordering and reporting of laboratory tests, maintaining the health of served populations, and documenting the full range of health care activities. Pathologists currently in practice and those in training need to acquire additional skills in informatics to be prepared to maintain a central role in patient care.**

Objective.—**To summarize the evolving landscape of pathology informatics, with particular attention to the preparation of pathologists for this discipline and to the possible influence of the new subspecialty certification in clinical informatics.**

Data Sources.—**Most of the information discussed is drawn from the authors' direct experience with informatics, resident and fellow education, and the organizations supporting these activities in pathology.**

Conclusions.—**The increasing reliance of medical practice on electronic health records and other clinical information systems is creating a greater need for physicians skilled in the use and management of these tools. The establishment of clinical informatics as a formal subspecialty in medicine will likely help secure a role for physicians within information management structures at health care institutions. Pathologists must actively engage in informatics to assure that our specialty is appropriately recognized and represented in this growing discipline.**

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Informatics is a term that means different things to different people. While most will accept the generic definition of "the science of information management," how that definition manifests itself in different clinical settings varies significantly.[1] The term *pathology informatics* has existed for decades, but the recent surge in implementation of electronic health record (EHR) systems and an expanding role of pathology laboratory information systems (LISs) in orchestrating the day-to-day activities in a pathology laboratory and in integrating with hospital systems has turned a new focus to this subspecialty area of pathology. With the increasing penetration of high-throughput data generating techniques such as next-generation sequencing and personalized medicine, both pathologists in practice and pathologists in training are beginning to realize that informatics is something they can no longer ignore.

Even academic medical centers are changing their attitudes toward informatics. While only a decade ago, many academic centers considered informatics to be a technical activity not meeting the scholarship requirements for academic promotion, now contributions to clinical information management activities are increasingly recognized as both scholarly and crucial to the future of health care. In fact, many institutions have chief medical information officers to manage the rapidly changing electronic environment. Large institutions and multi-institutional groups meet regularly to attend to issues of cyber crime; academic institutions have unique concerns for patient data protection, as well as for protection of research data. These are no small tasks.

Undoubtedly, computerized information management will have a significant role in the future (and current) practice of pathology. How does the discipline best prepare our trainees to fulfill that role and how do we give currently practicing pathologists the skills they need to use the essential aspects of informatics in their day-to-day work? While proposing a specific curriculum is outside of the scope of this article, a number of efforts are under way within the pathology professional societies to do just that. We will explore herein the elements of and approaches to pathology informatics training.

THE ROLE FOR INFORMATICS IN PATHOLOGY

One cannot contemplate pathology residency training (and the continuing education of practicing pathologists) in informatics without first considering the scope of information management activities that a pathologist in practice needs to (and will need to) be able to perform. As a baseline,

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From the Department of Pathology, Yale University School of Medicine, New Haven, Connecticut (Dr Sinard); the Department of Pathology, The Methodist Hospital, Houston, Texas (Dr Powell); and the Department of Pathology, The George Washington University Medical Center, Washington, DC (Dr Karcher).

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Reprints: John H. Sinard, MD, PhD, Department of Pathology, Yale University School of Medicine, 310 Cedar St, Brady Memorial Laboratory B38, PO Box 208023, New Haven, CT 06520-8023 (e-mail: john.sinard@yale.edu).

pathologists need to be adept at using electronic tools to gather information. This includes both the basic knowledge of their discipline, as well as information specific to a particular case. The body of knowledge that pathologists are expected to simply know and integrate into their decision-making process is growing on a daily basis. Pathologists need ready access to reference material (journal articles, staging information, reporting guides, etc), and this is more easily delivered to a variety of practice locations via electronic means. Clearly, all pathologists need to be able to use Web browsers for literature searches, as well as accessing various Web sites containing reference material. Note that access to online journals is not homogeneous across the pathology community, being more common at academic centers and less common among private practices. Beyond Internet access, pathologists should be proficient in the use of their LIS. This manages their day-to-day work flow, including (among many other things) patient and specimen identification, pending logs, sample aliquoting and tracking, stain ordering, result and report generation, tracking of turnaround times, and billing. While some pathologists may still use a largely paper-based work flow, relegating data entry into the LIS to support staff, increasing demands for both efficiency and patient safety are driving conversion toward greater direct interaction between the pathologist and the LIS. The computer terminal at the pathologist's desk or sign-out station is becoming as important a diagnostic tool as, for example, the telephone and the microscope.

As more and more institutions adopt EHR systems, in part as a response to efforts to meet "meaningful use" requirements of payment incentive programs sponsored by the Centers for Medicare and Medicaid Services and the Office of the National Coordinator for Health Information Technology, and to avoid penalties for not meeting meaningful use, all pathologists must become familiar with these systems. On the most obvious level, pathologists often need more clinical information than they receive on requisition forms or is typically available in the LIS to make an accurate diagnosis or provide consultation to clinicians; the EHR can be the quickest way to obtain needed clinical information, access imaging data, and learn about comorbidities. The use of EHRs with computerized provider order entry capabilities is changing the mind-set of physicians submitting specimens to pathology for evaluation. Because the order is being entered into the computer, many physicians assume that anything else relevant to the patient and the order already in the EHR is equally available to the pathologist and need not be specified on the requisition form or in the electronic order. Therefore, pathologists must often consult the EHR for the information not provided, at best a time-consuming and inefficient process and in some settings not even an option because not all pathologists have access to their own institution's EHR or the multiple EHRs of outreach clients, a situation often encountered in community practice and in the reference laboratory setting.

Just as the EHR computer screen is replacing the laboratory's paper requisition form, the EHR computer screen is also replacing the laboratory's printed result report. While pathologists often concern themselves with how their test results and paper reports look when printed out of their LIS, they must also begin to consider that many of the clinicians caring for the patient will never see this version of the results or report but rather an altered version resulting from the electronic transmission of the results from the LIS to the EHR, often with substantial loss of formatting. Because the major role of clinical laboratories is to communicate test results and diagnostic information, and because the structure of the test results and pathology reports can affect the accuracy and efficiency of that communication, laboratories producing complex annotated laboratory test results or building complicated diagnostic reports must consider how these results and reports will look after transmission to the EHR, where they will be viewed by the clinicians.

Finally, all pathologists must understand the capabilities of their LIS for meeting the quality assurance and patient safety mandates that come with running a CLIA-accredited laboratory. They must also know the regulatory restrictions that legislation such as the Health Insurance Portability and Accountability Act of 1996 places on the use of the information in their EHR for nontreatment purposes.

At a somewhat more selective level than "every pathologist," there needs to be a pathologist in each practice or group who takes responsibility for developing policies related to the proper use of the LIS and who is familiar with regulatory issues. The individual or individuals should have significant input into LIS feature acquisition and use, determining such things as laboratory work flow, the use of bar code–based tracking of specimens, interface setup and management, test result and report formats (including synoptic reporting), proficiency testing, diagnosis coding, and so forth. While many pathology groups have relegated the day-to-day management of their LIS to institutional information technology groups, a significant proportion of the decision-making authority should remain with the pathology group, and that requires an above-average expertise in pathology informatics. Currently, these roles are typically filled by pathologists without formal training in informatics. These pathology informaticists/informaticians are typically self-taught with respect to their informatics skills, and most of them have other professional responsibilities within the group.

Some pathologists go beyond a mere interest in informatics and take on a leadership role in their groups. They may manage an information technology staff, providing department-level support and management of the LIS. This does not happen in every group or practice, but its frequency is increasing. These directors of pathology informatics (or a similar title) are involved in system selection and in contracting and communicating with the LIS vendor. They also typically take on responsibility for selection, integration, and management of ancillary systems such as instrument interfacing, autoverification, system middleware, digital dictation and speech recognition, and so forth. Interaction with information technology groups at the institutional level, particularly those in charge of the EHR, is an important part of the role of a director of pathology informatics. Many will sit on institutional medical records and other relevant committees. They have primary responsibility for assuring the integrity of laboratory data transmitted to the EHR and should help with optimizing the display of laboratory data within the EHR. They should have a role in setting up computerized provider order entry functionality in the EHR, including the collection of pertinent data related to the tests being ordered. More advanced roles such as clinical decision support and test use monitoring and control represent an opportunity for pathology and pathologists to demonstrate their value to a

Table 1. Time Line for the Creation of the Subspecialty of Clinical Informatics

Year	Event
1991	The ABP proposes subspecialty certification in pathology informatics
1992	The ABMS tentatively accepts the concept, pending the development of questions for an examination
1995	Effort dies, in part because of an insufficient number of questions generated
March 2007	The AMIA begins the process of defining core competencies for the subspecialty of clinical informatics
November 2008	The AMIA board approves the proposed training requirements
July 2009	The ABPM agrees to sponsor the subspecialty application to the ABMS
March 2010	The ABPM submits the initial application to the ABMS
August 2010	The ABP decides to cosponsor, with the ABPM, the application to the ABMS for the approval of clinical informatics as a new certifiable subspecialty
February 2011	Committee on Certification, Subcertification, Recertification, and Maintenance of Certification of the ABMS
September 21, 2011	The ABMS approves clinical informatics as a new subspecialty
December 2012	The ACGME convenes a working group to develop the program requirements for a clinical informatics fellowship
March 2013	The ABPM releases "Study Guide Materials: Examination Content Outlines," detailing the scope of clinical informatics and the corresponding board examination
October 7–18, 2013	First administration of the board examination for clinical informatics subspecialty certification (by experience)
February 2014	Tentative date for the ACGME review/approval of the program requirements for clinical informatics training programs
July 2014	Planned implementation of the ACGME clinical informatics fellowship program requirements

Abbreviations: ABMS, American Board of Medical Specialties; ABP, American Board of Pathology; ABPM, American Board of Preventive Medicine; ACGME, Accreditation Council for Graduate Medical Education; AMIA, American Medical Informatics Association.

health care system beyond providing accurate and efficient laboratory services.

CLINICAL INFORMATICS AS A SUBSPECIALTY

Recently, the American Board of Medical Specialties approved a new board certification in clinical informatics, sponsored by the American Board of Preventive Medicine and cosponsored by the American Board of Pathology (see Table 1 for the time line), marking the acceptance of clinical informatics as a formal medical subspecialty. The first certification examination took place in October 2013 among candidates using a by-experience route to eligibility. Eventually, training in a formal fellowship training program accredited by the Accreditation Council for Graduate Medical Education (ACGME) will be required, and the ACGME is currently in the process of establishing requirements for clinical informatics training programs (see below).

The mere existence of this formal subspecialty, however, has significant philosophical implications for pathologists and pathology training in informatics. It is worth looking at the effects of the existence of other subspecialties in pathology on daily practice.[1] For example, neuropathology is a well-established subspecialty. This has resulted in essentially complete segregation of this material from the routine practice of pathology in larger medical centers. At places fortunate enough to have neuropathologists or simply pathologists with a significant interest in neuropathology, most general pathologists will reroute any cases related to the brain or spinal cord immediately on presentation; the slides do not even reach their microscope stage. Hematopathology is slightly less compartmentalized; most pathologists are willing to look at a lymph node or even a bone marrow specimen until the suspicion of a hematopathologic diagnosis reaches a certain level, and at that point the case is packaged up and transferred to a subspecialist for further evaluation and diagnosis. Immunohistochemistry was suggested at one point as a subspecialty, and a formal board examination was even offered for a short period. However, it was recognized that immunohistochemistry is a technique with applicability across many subspecialties, and as such all anatomic pathologists needed to be proficient in interpreting these results.

The other most recent subspecialty, and perhaps the closest example to clinical informatics, is molecular genetic pathology. The effect of this subspecialty on the work flow in pathology departments is still evolving. While there are clearly special skills needed to interpret the data generated by various molecular testing techniques, general pathologists have not totally divorced themselves from having a role in determining the likely significance of these test results and whether or not they should alter the histopathologic diagnosis for a case.

What will be the future effect of having some pathologists in a group certified in clinical informatics? How will this affect what pathologists not certified in clinical informatics deem as falling within the scope of their responsibilities and duties? This is difficult to predict. However, one effect is almost certain: the existence of a clinical informatics subspecialty will split the field into at least 2 tiers, separating those aspects of the discipline that every pathologist should know from those things that only a subspecialist should have to know. While the exact location of this dividing line within the spectrum of pathology informatics roles discussed in the previous section is not yet known, and will likely drift over time, understanding this separation is important in contemplating any specific curriculum for the incorporation of informatics training into pathology residency training programs and continuing education activities for practicing pathologists.

PATHOLOGY INFORMATICS VERSUS CLINICAL INFORMATICS

The ACGME has drafted the program requirements for fellowship training in clinical informatics, which will be sponsored and reviewed by the Residency Review Com-

mittee for the American Board of Preventive Medicine. Members of the working group currently developing these requirements represent the specialties of family medicine, preventive medicine, medical genetics, and pathology, with at least 1 member who serves as a chief medical information officer. The program requirements are broad, generic, and nonspecific, with the intention of allowing fellowship programs the flexibility to accommodate physicians in every specialty. However, areas of concentration have been identified and include pathology informatics/LISs, remote systems and telemedicine, algorithm development, diagnostic imaging, public health informatics, clinical and translational research, computational biology, regulatory informatics, data organization/user interfaces, and other specialty-specific areas of concentration that are not otherwise specified.

The ACGME Committee on Requirements is tentatively scheduled to review and approve the final program requirements in February 2014, allowing accreditation for programs starting in July 2014. It is anticipated that the current draft will be available on the ACGME Web site for public comment in the late summer of 2013. One of the more controversial aspects of the proposed requirements is the determination of an appropriate length of training, weighing the need for a significant experience against the realities of prolonged training and multiple fellowships for pathologist trainees and those in other specialties.

Informatics has been identified by both trainees and faculty as one of several areas of the pathology curriculum in need of improvement, including (for example) education in laboratory management and in genomics/precision medicine. A Pathology Residency Program Directors' Section of the Association of Pathology Chairs working group for education in informatics is currently being formed to examine existing published curricula. In addition, consistent with the ACGME milestones approach to training, objective measures to assess the performance of trainees in informatics will be required.

A CURRICULUM FOR PATHOLOGY INFORMATICS

When surveyed, most pathology residency training programs report offering formal informatics training.[2,3] Within descriptions of pathology training curricula for residents, informatics has traditionally been included under laboratory management.[4] Proposed curricula for pathology informatics training during residency have been published,[5,6] and a "curriculum wiki" has been created.[7,8] These curricula focus on the vocabulary and domain knowledge of the discipline, ranging from the basics of computer hardware and software through networking, databases, LISs, electronic data encoding, messaging and interfaces, digital imaging, and security and regulatory issues. While informatics is clearly a dynamic field, the vast majority of the fundamental concepts are rather stable, and there is a well-recognized need for pathologists to develop fluency with these concepts. In addition to these residency program curricula, some curricula have been recently published for more specialized pathology informatics fellowship training.[9–11]

All of these proposed curricula were developed before the existence of the formal subspecialty in clinical informatics. With the creation of this formal subspecialty, and the implicit separation of informatics knowledge into the 2 tiers of "what every pathologist should know" and "what informatics subspecialists should know," the question will be asked whether or not the proposed knowledge base described by these curricula applies to the "all pathologists" tier or the "informatics subspecialists" tier. Does every pathologist need to understand the fundamentals of a relational database, how Health Level-7 (HL-7) is used for communication between the LIS and the EHR, or how pixels form a digital image? As a partial answer to this, consider the Krebs cycle. Every pathologist learned the Krebs cycle when a medical student. Most pathologists would claim they never use this knowledge. However, whenever pathologists look at tissue undergoing ischemic necrosis, their understanding of that process is built on knowing about the cellular metabolic pathways that use oxygen to make adenosine triphosphate. In a similar way, when designing the format of laboratory test results or building a synoptic report, the pathologist should be thinking about how the results or report will look in the EHR when the treating clinician sees them, and that requires knowing how and in what format the results and report reach the EHR. When searching for cases for a small academic study, the resident should understand how the search request is translated into Structured Query Language (SQL) and what criteria will affect the speed at which that search can be conducted. Thus, simply restricting much of the technical knowledge of pathology informatics to informatics subspecialists is almost certainly not the correct path to take.

Revisiting the Competencies

Much of the literature and indeed the work spent to date on the development of a pathology informatics curriculum has focused on the knowledge competency. This competency is the most straightforward to teach and to objectively assess. However, the purpose of the knowledge is to allow it to be applied to promote patient care. In much the same way that pathology residents learn diagnostic criteria so that this knowledge can be applied to resolving the differential diagnosis for a specific case, trainees in pathology informatics must have an opportunity to use the fundamental informatics knowledge they acquire in their day-to-day care of patients. These activities, which would probably best fall within the patient care competency, are typically not provided as a separate rotation but are rather integrated into the daily work of the residents, enforcing the use of informatics as a tool to promote better laboratory service and pathology practice. Enabling these experiences within the training environment is arguably a more important part of any informatics curriculum than the "basic science" lectures in informatics. This part of the curriculum is more difficult to script because many of the aspects of its implementation are dependent on the particulars of the departmental and institutional information management environment. However, examples abound and would include the following: learning about automation pipelines, accessing the Internet at previewing and sign-out stations, taking digital gross photographs[12] and reviewing them with the attending at sign-out, routinely using the LIS, using LIS enhancements to promote patient safety (eg, specimen bar coding),[13] accessing the institutional EHR system(s), expecting residents to look up histories (when needed) as part of their routine evaluation of cases and clinical consultations, and so forth. The preparation and presentation of digital conferences, especially those incorporating digital images, also require the use of informatics tools. In addition,

those residency programs that are using telemicroscopy in its many forms, which may include digitizing slides for medical student teaching, and/or archiving consultations or real-time intraoperative consultation, for example, can provide hands-on tips to other training programs about how to incorporate these particular modalities into current daily practice. Other examples of the practical use of informatics skills in daily practice include criteria for autoverification of test results, clinical decision support at the time of computerized order entry, the unique aspects and regulatory requirements of information systems in the blood bank, and evaluation and interpretation of the results of molecular and genomic testing.

Informatics, however, is not limited to the use of computers and digital technology. An important part of the informatics process is work flow analysis, data gathering, process redesign, project prioritization and management, solution design, human factors engineering, deployment planning and execution, and outcome assessment.[14] These activities would probably best fall under the practice-based learning and improvement competency. They are much more difficult to teach and evaluate. Few practices would be willing to hand over such decisions to trainees, and providing them with a role in these processes (while possible) does not typically fit in well with standard pathology rotations, which are typically too short to allow the trainee to have a significant role in the process. Attendance at planning meetings, either as a separate rotation or integrated into another time-flexible rotation, is one way to expose trainees to this process.

Pathologists and pathology trainees also have an opportunity to participate in the use of medical data in the context of health systems–based care delivery and population health monitoring and promotion. This falls squarely within the systems-based practice competency. Clinical LISs have a wealth of information related to test use patterns within the health system. By correlating these data with diagnosis codes and ideally even patient outcome, there is a tremendous opportunity for the pathologist to have a major role in clinical decision support and the evaluation of new care delivery models. In addition, the discrete, quantitative data present in LISs are ideally suited for larger-scale population statistical analysis.

Finally, there are many opportunities for trainees to use informatics tools as part of their participation in scholarly activities during residency. Where possible, activities such as case identification for inclusion in a study or clinical data gathering for longitudinal or utilization analyses should not be handed off to information technology groups, but rather the trainee should be involved in learning how to retrieve relevant data and perform the data retrieval. This will afford residents the greatest opportunity to learn not only the capabilities and limitations of these tools but also fundamental concepts such as the value of coding and consistent data entry.

What Should Residency Training Programs Be Doing Now?

Teaching the basic knowledge aspects of informatics can be integrated into the formal lecture/conference series that already exists within the residency program. This can be done as part of the management training but is probably best designated specifically as informatics to make it clear to the residents that they are receiving formal training in this subspecialty. If the department lacks faculty with sufficient expertise in informatics to deliver these lectures, increasing numbers of resources are becoming available online that the faculty can draw on, or the program may be able to enlist the assistance of members of other departments or even institutional information technology professionals to assist with these lectures. One of the more difficult aspects of delivering these lectures will be compensating for the marked variation in background that the trainees will have in informatics. Some will be true novices to the discipline, while others may be highly conversant in computer technology and may even have already done some software development.

Perhaps the most valuable initial steps in strengthening informatics training within pathology residency programs would be an examination of the practice environment and available facilities and the identification of ways in which to integrate the use of informatics concepts and tools in day-to-day practice. This is not simply a matter of providing each resident with a computer. Rather, it involves assuring that residents have access privileges to institutional patient care systems, receive training in the proper use of these systems, and have ready access to them at their workstations. It involves assuring that digital cameras are available for gross and microscopic photography. Most important, the teaching faculty must require and expect the trainees to use these tools and verify that they are using them when appropriate.

What About Pathologists Already in Practice?

Although it is important to focus educational efforts in informatics on pathology residents and fellows because pathology and clinical informatics are sure to be intrinsic to almost every aspect of their future practice of medicine, pathologists already in practice must also acquire enough informatics knowledge and master enough of an informatics skill set to survive and thrive today and in the years they have left in practice. For this reason, it is also important to provide continuing education in informatics to practicing pathologists. Similar to the situation with pathology trainees, the nature and scope of informatics training for experienced pathologists should necessarily extend from the most basic principles appropriate for all practicing pathologists to understand to significantly more advanced informatics knowledge and skills. Because of the necessities of group or departmental leadership, or the need for a pathology group to have at least 1 informatics specialist in its ranks, selected practicing pathologists must have or acquire more detailed knowledge of information systems, databases, networks, interfaces, and middleware, as well as how these various tools can be used to extract necessary information and provide accurate, properly formatted, maximally actionable, and appropriately interpretable laboratory results and pathology reports suitable for transmission to potentially multiple different clinical information systems.

In the course of training and practice, most experienced pathologists have acquired at least a working knowledge of many aspects of informatics. By simply signing onto and using their laboratory's LIS, the average practicing pathologist already has at least a rudimentary knowledge of order entry, case work flow, report generation, and electronic transmission of laboratory results and pathology reports. As paper-based medical records have begun to be phased out in many practice settings, some pathologists have learned at least the basics of clinical data searching within the hospital's EHR system and on a more limited basis across multiple other clinical information systems (at least in those

Table 2. Informatics Training for Pathologists
Summary
• Information management is a fundamental part of the practice of pathology Pathologists need access to information to integrate into pathology consultations Pathologists need to deliver information so that it can be readily and accurately assimilated by clinical teams • Directing and managing an efficient and effective clinical laboratory requires deep familiarity with the LIS and its interface(s) with the EHR and other clinical information systems Managing laboratory work flow Meeting regulatory requirements Producing and transmitting accurate, readily understandable, and maximally actionable clinical laboratory test results and diagnostic reports • The new clinical informatics subspecialty certification will likely segregate informatics skills into those that every pathologist should possess and those in which only a subspecialist need be proficient • Instruction in informatics should be an integral part of pathology resident training; informatics curricula for residents should include didactic instruction but, most important, an opportunity to use informatics tools in daily practice • Practicing pathologists should obtain sufficient instruction in informatics to allow them to effectively direct laboratory operations and fully use the LIS, EHR, and other relevant clinical information systems • Informatics knowledge creates opportunities for pathologists within their practices and within their institutions

Abbreviations: EHR, electronic health record; LIS, laboratory information system.

places that provide the pathologists with access to the EHR system). Because this "on the job" learning of basic informatics skills has often taken place in an unsystematic fashion and without a background in the principles underlying many LIS functions, most pathologists are still in need of at least some basic instruction in these underlying principles. With few exceptions, the practicing pathologists involved in informatics at a more advanced level have acquired their higher-level knowledge and skills through reading, self-study, and informal training by technical informatics staff members and/or vendors, as well as by attending occasional formal training sessions at regional and national meetings. Although these more advanced practitioners of informatics often possess a broad practice–oriented skill set, they often lack sophisticated knowledge of information system architecture, interface functionality, electronic data encoding, system security and privacy requirements, and other vitally important aspects of modern clinical information system design and use. Possession of this type of knowledge is of particular importance during the selection process of a LIS, as well as part of the day-to-day operation and management of these systems, each of which should involve 1 or more pathologists in any sizable pathology group or department.

To meet the basic informatics educational needs of most practicing pathologists, it should be sufficient for these pathologists to access and use instructional materials that cover the basics of information technology and pathology informatics. These educational materials could be accessed online, in the form of self-contained instructional programs or Webinars, or through attendance at courses or workshops at regional and national pathology meetings. Many such instructional materials and workshops are already available,[15–18] and others are currently in development. The overall goal of these basic informatics courses and instructional programs is to provide the average practicing pathologist with the knowledge and skills necessary to optimize his or her day-to-day use of the LIS and/or EHR, including an understanding of the selection and use of basic informatics tools available in these systems.

Although more advanced information technology and informatics topics may also be well covered and appropriately mastered using electronic media available online, in-person courses and workshops varying from a few hours to multiple days in length may be more appropriate for some by virtue of the complexity of some of these topics. For practicing pathologists already involved in high-level informatics activities, in-person learning activities offer a more intensive experience, with the opportunity for hands-on practical exercises and interaction with highly knowledgeable instructors and fellow learners.

Beyond the need for knowledge and skills in mainline pathology and clinical informatics, selected practicing pathologists may also need to get significantly involved in newer emerging informatics methods and activities.[19] Digital imaging and telepathology are already part of day-to-day practice in some settings, and these technologies are certain to be used on a more widespread basis in the coming years. Likewise, as genomic analysis and precision medicine rapidly expand, the need to understand and use the principles of bioinformatics, computational biology, and large data set analysis will become more important for selected pathologists already in practice. To meet the needs of these pathologists, some form of formal instruction in these emerging technologies will be of particular importance. Courses and workshops in these and related areas are already available,[20–22] and others are sure to be developed.

CONCLUSION

The landscape of medical practice is changing. As the use of EHRs increases and as clinical care relies more heavily on the use of those systems, much of the day-to-day life of physicians will be dictated by the work flow of EHR systems. Physicians have traditionally relegated the control and management of computer systems to institutional administration, but that has to change. The creation of a formal subspecialty in clinical informatics not only recognizes the potential value that can be obtained by involving informatics-trained physicians in the management of health information but also creates a pathway for physicians to gain added credibility in this new role. Pathologists in particular are well positioned to have a major influence in this area. Their long-standing experience with data man-

agement, history of early adoption of electronic systems in their practices, and focus on integrating information from multiple sources into a coherent diagnosis render them and us particularly qualified to become proficient in health information management.[23] Appropriate exposure to and training in informatics will be essential for pathologists to continue to provide valuable contributions to clinical care (Table 2). This is also a chance for pathologists to increase their visibility and value within the greater health care system and their own health care organizations. However, this opportunity is by no means being reserved for pathology. Motivating pathologists to pursue these roles, providing continuing medical education opportunities in informatics for pathologists in practice, and developing a strong informatics component to residency training programs will all help advance this transformational future of the practice of medicine.

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