



Moving toward multimedia electronic health records: how do we get there?

Belinda Seto,¹ Charles Friedman²

¹NIBIB, NIH, Bethesda, Maryland, USA

²School of Information, University of Michigan, Ann Arbor, Michigan, USA

Correspondence to

Dr Belinda Seto, National Institute of Biomedical Imaging and Bioengineering, National Institutes of Health, 6707 Democracy Blvd, Suite 202, MSC-5477, Bethesda, MD 20892-5477, USA; setob@mail.nih.gov

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ABSTRACT

This report, based on a workshop jointly sponsored the National Institute of Biomedical Imaging and Biomedical Engineering and the Office of the National Coordinator for Health Information Technology, examines the role and value of images as multimedia data in electronic health records (EHRs). The workshop, attended by a wide range of stakeholders, was motivated in part by the absence of image data from discussions of meaningful use of health information technology. Collectively, the workshop presenters and participants argued that images are not ancillary data and should be central to health information systems to facilitate clinical decisions and higher quality, efficiency, and safety of care. They emphasized that the imaging community has already developed standards that form the basis of interoperability. Despite the apparent value of images, workshop participants also identified challenges and barriers to their implementation within EHRs. Weighing the opportunities and challenges, workshop participants provided their perspectives on possible paths forward toward fully multimedia EHRs.

INTRODUCTION

The National Institute of Biomedical Imaging and Bioengineering (NIBIB) and the Office of the National Coordinator for Health Information Technology (ONC) co-sponsored a workshop, 'Images, Electronic Health Records, and Meaningful Use: A Vision for the Future,' in January 2011. The workshop explored how electronic health records (EHRs) could, over time, become multimedia devices integrating images, alphanumeric, and other forms of data. The workshop, albeit not designed as a policy forum, provided a venue for a diverse group of approximately 100 stakeholders—including primary care physicians, medical specialists, hospital and health system leaders, payers, technology experts, and health IT vendors—to share their vision and perspectives on both technical and clinical implementation issues and how these issues may inform the evolving concept of 'meaningful use' of EHRs under the Health Information Technology for Economic and Clinical Health Act, 2009 (HITECH).¹ The workshop was motivated in part by the absence of reference to images in the Stage 1 'meaningful use' regulation that specifies requirements to obtain financial incentives for EHRs, starting in 2011.² This report presents a summary of viewpoints expressed at the workshop from panel presentations and resulting discussions, and the concluding session. As such, the viewpoints presented by the participants are the primary data source for this report. It should be noted that while this report focuses on images, the practical issues and challenges in implementing

multimedia technology apply to other forms of data—for example, genomics, proteomics, waveforms, and sounds—that are of rapidly emerging importance but not currently part of EHR functionality or contemplated as part of meaningful use.

IMAGES ARE NOT ANCILLARY DATA

The care providers at the workshop, particularly, emphasized that images are routinely used for screening, surveillance, and diagnosis, and as part of therapy. To the extent that imaging data are used in planning and clinical decision making, they should be as accessible as data that are stored in alphanumeric form. However, the informed but anecdotal reports of conference participants indicated that it is not a common practice to share images as part of an EHR, either between providers or across institutions. In practice, scans are shared by transporting data on physical media such as CDs. Published reports cited by workshop presenters pointed to examples where lack of interoperability between systems resulted in data that could not be imported and interpreted,^{3,4} resulting in delayed or incomplete diagnosis and repeated scans. These examples illustrate the need to share images seamlessly, following patient authorization, in order to improve patient care and disease management, and reduce unnecessary procedures.

A possible solution to address image sharing and patient privacy may come from a collaborative NIBIB/Radiological Society of North America (RSNA) image sharing initiative.⁵ This project demonstrates how image sharing can be accomplished, with patient control, using the IHE (Integrating the Healthcare Enterprise) profiles and DICOM (Digital Imaging and Communication in Medicine)/HL7 (Health Level 7) standards. This project uses industry-supplied personal health records for patient and individual provider access, and uses cloud technology and an edge server at each institution in the network. The goal is to ultimately supersede the use of CDs as media for image exchange.

Workshop participants argued that images should be integral to EHRs because they capture information which cannot be easily summarized in text. They are also crucial to providing best advice to patients. In a study of 35 cases of abdominal CT scans, Iyer *et al*⁶ reported that the referring physicians preferred to have radiology reports with embedded images over text-only reports because, with the actual images, they were more confident in making clinical decisions. Furthermore, they formulate patient care and disease management plans based on images and the reports. Health information systems that integrate imaging data



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with clinical decision support will enable decisions that are based on guidelines, evidence from the literature, medical knowledge, and comprehensive patient data. The entire set of images does not necessarily need to be directly included with the records but does need to be linked in a way that is completely transparent to the user. Images (and other data) can be distributed at multiple sites outside the physician's office or the health center, although there should be one source of truth for patient information that can draw from a federated information system.

IMAGES SERVE A WIDE RANGE OF CLINICAL NEEDS

Imaging data are produced and/or used by all clinicians, across a range of image types from dental x-rays, dermatology photographs, and pathology slides to CT images for oncologists and magnetic resonance images. While all specialties consider images to be important, participants from different specialties reported that each has different requirements for acquiring, viewing, and interpreting images that are essential to diagnosis and treatment. This is particularly relevant for radiologic image-intensive specialties, including obstetrics, radiation oncology, cardiology, vascular surgery, orthopedics, neurology, neurosurgery, pulmonary medicine, ophthalmology, ENT, general surgery, and urology. We cite here three illustrative examples that were presented and discussed at the workshop:

- ▶ Cardiologists employ a full range of imaging modalities: chest x-ray, echocardiography, PET, CT, MR angiography, and hand-held ultrasound devices. Cardiac imaging is crucial to understanding disease, establishing diagnosis and treatment, deciding between surgical and interventional treatment, guiding that treatment, and assessing treatment efficacy or status change. Cardiac images may be acquired in multiple sites including offices, mobile units, or hospitals. Images are also needed in operating rooms and intensive care units in real time. The challenge, however, for EHR and cardiac imaging is to integrate comprehensive patient data at the point of care and to include imaging informatics to translate data into knowledge for clinical decision support. These functionalities are essential to diagnosis and treatment determination. While picture archiving and communication systems (PACS) are closely interfaced with radiology information systems, they are still largely separate from EHRs. Currently, most EHRs have an image viewer that pulls images from separate PACS and cannot support image reconstruction or other forms of advanced imaging.
- ▶ For different clinical scenarios, neurosurgeons may require different complexities of images and image access. For example, advanced imaging techniques for volumetric scans are required for spatial reconciliation or fusion with different image sets for surgical resection of seizure foci. Neurosurgeons may require historical images for reference. It is also desirable to be able to combine image data with clinical data for diagnostic purposes.
- ▶ Obstetric and gynecologic physicians deal with a patient population that moves from one practice to another. For these providers, images must be transportable between providers and annotated in order to have consistent readings and interpretations. Ready access to images is essential for distant consultation, second opinion, and telemedicine.

'MULTIMEDIA' EHRs THAT INTEGRATE ALPHANUMERIC AND IMAGE DATA

A number of healthcare systems in the USA have implemented EHRs with different levels of integration of digital images with

other forms of data. Most notable among these is the Veterans' Administration's (VA) VistA system. With 152 medical centers and over 1000 outpatient clinics, the VA has integrated images from virtually all the specialties into its EHRs.ⁱ Because it can operate largely as a self-contained system, the VA has the ability to impose standards and methods for capturing, storing, transmitting, and accessing images across all of its facilities. Online images are linked to radiology reports, medical procedures, surgical reports, pathology results, consults, progress reports, etc, which can be shared seamlessly across the network.

The Mayo Clinic, a non-profit, large, integrated, multidisciplinary patient-focused group practice, initially implemented an EHR in 1995, and has had a fully functional, paperless EHR since 2004. Mayo's geographical distribution across five states and over 65 communities requires an EHR system that is capable of meeting varying levels and types of demand. Mayo handles a large volume of images: 775 000 images in total are processed each day, of which 444 000 are radiology images. Mayo also receives and must process 216 000 outside image sets per day on CDs. The EHR system affords access to any image, anywhere and anytime. The reported benefits to patients include reduced unnecessary procedures, reduced costs and radiation exposure, and improved care through rapid access to comparison images. Enterprise access to digital images, radiological and non-radiological, has reduced duplicative images. Digital images have reduced costs per study by 40% as compared to films.ⁱⁱ

The Massachusetts General Hospital has built the capability to distribute images via its enterprise EHR system since 2000. The system continues to be enhanced with integrated computerized procedure order entry and clinical decision support for radiology. The immediate benefit of these enhancements is evident through a reported 19% reduction in radiological tests from 2005 to 2008.^{iii 7}

Image integration in the UK was also described at the workshop. Compared to the USA, the UK delivers a greater fraction of care in general practitioner (GP) settings. The National Health Service information systems make images available to GPs. GPs also capture photographs that are exchanged in routine care between physicians and patients and across care settings. The UK has experienced bandwidth challenges in sharing large data files such as thin slice CT images.

STANDARDS AND INTEROPERABILITY

Workshop participants described the robust standards, developed by the imaging community, that are essential to image exchange, and lay the foundation for integration into EHRs. DICOM standards for images were initially adopted in 1993 and have been used world-wide since 1995. These standards extend beyond radiology to include cardiology, dentistry, endoscopy, mammography, ophthalmology, orthopedics, pathology, pediatrics, radiation therapy, surgery, and veterinary medicine. DICOM promotes interoperability through consistent headers that include patient identifier, clinical context, and image characteristics. DICOM standards are also used for waveform data such as ECG.

Presenters reported how hospitals, imaging centers, and physician practices, by taking advantage of these standards, can today implement cross-enterprise document sharing infrastructures that transmit images and image reports. Beyond these

ⁱData presented by Dr Ruth Dayhoff, VA at the workshop.

ⁱⁱData presented by Dr Nina Schwenk, Mayo Clinic at the workshop.

ⁱⁱⁱData presented by Dr Keith Dreyer, Massachusetts General Hospital, at the workshop.

institutional boundaries, physicians and systems within a regional health information network can request images and reports based on a cross-enterprise registry model where there is a clearinghouse for patient identity management, document or image registry, and access security. The query for data, documents, and notification of data availability are centralized at the registry. For example, in response to a request or query for data, a patient would authorize access to the data via the clearinghouse which interfaces with the hospitals or image centers where the data were generated and stored. The interface is achieved through an edge server. The clearinghouse would retrieve the document for the requester.

IMAGES AND BANDWIDTH

Workshop participants discussed the bandwidth requirements for national-scale image exchange. They reported that, particularly for rural and underserved communities, bandwidth that is adequate to support image exchange cannot be assumed. However, there are a number of approaches to transmitting large image datasets that can overcome the bandwidth barrier: (1) compression reduces the size of the dataset without compromising the resolution of the images; (2) just-in-time streaming data delivery delivers to the user only that portion of the image dataset that is needed and JPEG rendition allows the viewing of images with the transfer of only a fraction of the image data file; (3) server-based rendering locates an advanced visualization engine on the server side and allows direct access to the PACS archive; and (4) optimized presentation allows viewing of image data in a prioritized order. Taken together, these methods can reduce bandwidth demand, making image-sharing possible using the commodity internet resources currently available at most practice sites.

CONCLUSION: A PATHWAY TOWARD MULTIMEDIA EHRs

The conference participants pointed to the critical role of image data in providing quality healthcare, and emphasized the need to link images to the associated structured reports in order to present a comprehensive dataset for the care providers to enable

informed decisions and safe and best clinical practice. While some exceptional examples of image access and integration were described, most practitioners do not enjoy this capability. While 83% of US hospitals in 2009 had implemented the viewing function for radiology images or radiology reports in their EHRs in at least one unit of the organization,⁸ hospitals still lack the capability to integrate image data as a component of the enterprise information systems. Clinical decision support systems that employ multimedia data to support comprehensive patient management are scarce.

While it was not the role of this conference to provide advice to federal rulemakers, the participants identified many mechanisms through which the policy priorities of all stages of meaningful use could be achieved through inclusion of multimedia capabilities in EHRs. The task falls to the rulemaking bodies and the federal advisory committees who are helping to guide them, to consider the role of images in this important national program.

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