Interoperability is a major focus of the quickly evolving world of Health IT. Easy, yet secure and confidential exchange of imaging exams and the associated reports must be a part of the solutions that are implemented. The availability of historical exams is essential in providing a quality interpretation and reducing inappropriate utilization of imaging services.

Today, the exchange of imaging exams is most often achieved via a compact disc. We describe the virtues of this solution as well as challenges that have surfaced. Internet- and cloud-based technologies employed for many consumer services can provide a better solution. Vendors are making these solutions available.

Standards for Internet-based exchange are emerging. Just as radiology converged on DICOM as a standard to store and view images, we need a common exchange standard. We will review the existing standards and how they are organized into useful workflows through Integrating the Healthcare Enterprise profiles. Integrating the Healthcare Enterprise and standards development processes are discussed. Health care and the domain of radiology must stay current with quickly evolving Internet standards.

The successful use of the “cloud” will depend on both the technologies and the policies put into place around them, both of which we discuss. The radiology community must lead the way and provide a solution that works for radiologists and clinicians with use of the electronic medical record. We describe features we believe radiologists should consider when adding Internet-based exchange solutions to their practice.

Key Words: Cloud, CDs, IHE, data security, inappropriate utilization

caring for the same patient, can be made available at various sites;
• Images and reports can be contemporaneously available at the point of care.

Image Sharing—Who Participates?
The following functions and environments play a role in image sharing:
• Primary interpreting radiologist (site generating the initial data)
• Referring physician
• Consulting physician
• Other radiologist (“2nd opinion”)
• Other hospital(s) or health care enterprise
• Clinical trial
• Patient
• Patient surrogate

Image Sharing—How?
Image sharing can be accomplished through the following means:
• PACS access
• Film
• Compact disc (CD)
• Online (Internet, “cloud”)

A PACS can itself be employed as a means of sharing images. Access rights to a PACS can be extended to providers outside the local enterprise. Security and confidentiality risks are associated with extending privileges to individuals not normally credentialed in an enterprise PACS. One must take care to see that the appropriate legal agreements, policies, and practices are put into place and explained to the “outside” user. Keep in mind that one is usually opening the door to the entire archive in such a scenario.

Film-based image interpretation still exists, particularly in the offices of nonradiologist providers. These exams may provide relevant information in the evaluation of the patient. Offices that produce primarily film are rarely capable of creating copies. Thus, patients shoulder the burden of carrying the only existing copy, ie, the one from the original examination, to subsequent providers. This process is cumbersome but should not be bypassed, particularly when the prior exam can assist in the treatment of a patient. Radiology offices frequently digitize and import these exams into a PACS. A tradeoff results from easier accessibility to the data versus degradation of the exam in the process of importation.

Conceptually, the CD appeared to provide the ideal solution for image exchange. Despite the significant advantages of CDs as a transport medium compared with film, several challenges have arisen. CDs remain the most common means of exchanging imaging data, and several steps can make this process more useful and less burdensome.

Online image exchange using the cloud is now available. In other areas of life, businesses have become accustomed to moving many types of information via the Internet. Music, photos, videos, and financial information are some of the data transferred using cloud technology. Society clearly finds this means of information exchange efficient and desirable. Acceptance of this relatively secure exchange of confidential information across the Internet indicates a reasonable level of trust by users of this technology. However, the challenge of ensuring the highest level of security and confidentiality for Internet-shared health care data is not trivial. Experience with the current, commonly used data types may inform the pursuit of health care information exchange.

Current and future Internet technologies are exciting, dynamic, and offer opportunities to promote the seamless exchange of health care data. As newly developed solutions are implemented, they must take into account the fact that the medical imaging profession has experienced tremendous growth, in part through the observance of standards such as DICOM and Health Level 7 (HL7). Ideally, new exchange technologies will respect these standards that support hardware interoperability while leveraging the advantages of Internet-based information exchange.

Both DICOM and HL7 are constantly evolving. A current focus is to keep both current with modern Internet technology. Many applications we all use daily on the Internet are based on RESTful services. REST is an acronym for Representational State Transfer. This architecture is commonly used by large organizations, including Google, Yahoo, Microsoft, and Amazon, to communicate with end-users through a browser. This efficient means of communicating information allows more-complex processing behind the scenes.

New DICOM RESTful services are intended to allow the imaging field to leverage these modern Internet technologies. These services include QIDO-RS (query based on ID for DICOM objects by RESTful Services) to query for images, WADO-RS (web access to DICOM objects using RESTful Services) to retrieve images, and STOW-RS (store over the web by RESTful Services) to store imaging data. HL7 is in the midst of its Fast Healthcare Interoperable Resource Project (FHIR®). In a similar manner, this project is intended to bring RESTful services to the HL7 standards.

INTEGRATING THE HEALTH CARE ENTERPRISE
Integrating the Healthcare Enterprise (IHE) is an endeavor founded in 1998 and formally incorporated in 2007; the IHE mission is directed at enabling transparent interoperability between the many systems used throughout health care enterprises. This interoperability is accomplished by identifying common workflows, the systems used, the transactions between these systems, and the existing standards (DICOM, HL7, etc.) that might be employed for these transactions. End-users, engineers,
and other technical experts work together to organize these factors into so-called “IHE profiles” that can be used to solve a specific workflow challenge. When IHE profiles are followed by vendors, their products will have a consistent expected behavior and can then be used together in a “plug-and-play” fashion. The end-user can have a well-defined expectation with regard to what a product can do and specifically what its output will be. Connecting systems becomes easier and less expensive. There should be little need for customization in such an environment.

The entire IHE process is intended to streamline the purchase of IT solutions and make them less expensive. The radiologist with only a minimal-to-moderate level of technological knowledge should be able to make an intelligent purchase without the assistance of an engineering consultant. Although a purchase may be plug and play, it does not mean that the solution is not technically sophisticated. However, it should be easily deployable into an existing legacy environment, have minimal interface needs, and be ready to use. The radiologist should be able to focus on learning the functional details of the solution and not be distracted by trying to create an interface of the solution with the surrounding environment.

IHE International—the Organization
IHE activity is divided into “development” and “deployment.” Deployment activity is broken up by international regions, such as IHE USA, IHE Japan, etc. The deployment groups are responsible for publicizing and instantiating the IHE profiles in their region or country. In addition, they may help modify IHE profiles that require customization for a specific geographic area.

IHE “development domains” support work to develop IHE “integration profiles.” These groups represent health care specialties as follows:

- IHE Anatomic Pathology (ANAPATH)
- IHE Cardiology (CARD)
- IHE Dental (DENT)
- IHE Endoscopy
- IHE Eye Care (EYECARE)
- IHE IT Infrastructure (ITI)
- IHE Laboratory (LAB)
- IHE Patient Care Coordination (PCC)
- IHE Patient Care Device (PCD)
- IHE Pharmacy (PHARM)
- IHE Quality, Research, and Public Health (QRPH)
- IHE Radiation Oncology (RO)
- IHE Radiology (RAD).

These domains have international membership. Yearly, they identify workflow processes that would benefit from a formal profile. They then gather the appropriate end-users and technical developers to work through the details of the profile. This process may take place over one to several years.

IHE profiles are published as part of the IHE Technical Framework [6] for each of the domains. The Technical Framework is actually published in 2 volumes: Integration Profiles (Volume 1) and Technical Framework (Volume 2). Volume 1 describes the clinical need, use cases, and the subsequent individual actors and transactions for each profile. Volume 2 describes the technical details and specifications for each transaction.

These documents are publicly available and provide the technical specifications and system implementation guidance that vendors should follow. Customers should familiarize themselves with relevant profiles and then specify compliance with these during the request for proposal and contracting process.

IHE Radiology
IHE Radiology is the oldest domain and has a robust portfolio of profiles:

- Radiology Scheduled Workflow (SWF)
- Patient Information Reconciliation (PIR)
- Consistent Presentation of Images (CPI)
- Presentation of Grouped Procedures (PGP)
- Access to Radiology Information (ARI)
- Key Image Note (KIN)
- Simple Image and Numeric Report (SINR)
- Charge Posting (CHG)
- Postprocessing Workflow (PWF)
- Reporting Workflow (RWF)
- Evidence Documents (ED)
- Portable Data for Imaging (PDI)
- Nuclear Medicine Image (NMI)
- Cross-Enterprise Document Sharing for Imaging (XDS-I)
- Mammography Image (MAMMO)
- Import Reconciliation Workflow (IRWF)
- Teaching File and Clinical Trial Export (TCE).

These profiles fall into 1 of 3 classes: (1) content profiles that address the management of a particular type of content object; (2) workflow profiles that address the management of the workflow process by which content is created; and (3) infrastructure profiles that address departmental issues.

Each year, existing profiles are refined and new profiles are developed as new technologies emerge and workflows evolve. When a new profile is believed to be finished, it is published for trial implementation. Early experience may result in further refinement, after which the profile is published as final. Over the years, as changes are brought forward, revised versions are published. As the numbers of domains have expanded, work on various profiles has started to overlap. IHE International has provided a mechanism to reconcile overlapping profiles, retire or deprecate some, and reference the “transactions” and actors of one domain in the work of another. This work advances the goal of transparent interoperability and prevents redundant efforts. The
profiles of the IT Infrastructure domain have often found reuse in radiology.

**IHE Profiles**

**The development process.** The IHE profile development process involves the following:

1. Define a workflow problem
2. Identify experts who will work to develop the profile
3. Identify the systems or “actors” and the transactions that will take place among them
4. Identify the existing standards that are applicable for the transactions
5. Develop a consensus as to how the actors should work together, which transactions are applicable, and the standards that are to be followed
6. Formally propose this solution as an IHE profile
7. Release the proposed profile for public comment and revise accordingly
8. Release the revised profile for “trial implementation”
9. Allow testing by vendors interested in providing solutions based on the profile. Such testing takes place several times a year, internationally, at IHE Connectathons.
10. Finalize the profile by continuing to allow vendors to test and document that their product has tested successfully for the given profile. They may publish an “integration statement” indicating that they have successfully tested a profile, thereby reassuring customers that the product will behave in an expected fashion.

**Actors and transactions.** Once the community has identified a workflow that it wishes to develop into an IHE profile, the first step is to identify the systems involved. These systems and their component modules are the actors. This identification needs to be done to a very granular level. Once all the actors are identified, the transactions that take place among them can be identified. In most cases, the transactions come from various existing standards, some that may compete with one another. Then, the task of the development team is to select the most desirable transaction.

**Cross-enterprise document sharing.** Cross-enterprise document sharing (XDS) is a set of recently developed profiles directed specifically at the exchange of health care information between legally disparate enterprises, including individual providers and large health care systems. The IHE ITI domain designed XDS to describe the transactions needed in a health information exchange (IHE; Fig. 1). The data types are numerous and include discrete lab data as well as text data, such as a medical summary. The information starts out at the local site where it was generated, the “document source.” It is then registered in the HIE, “document registry” so that it can be discovered by others participating in the exchange (or in IHE terms, the “affinity domain”). A
duplicate copy is stored in the document repository. When the patient travels to a different participating entity, that provider, known as the “document consumer,” can query the HIE if proper consent, which may be governed by local policy, is obtained. The document consumer may then discover and retrieve the available information. These actors and transactions are depicted in Figure 1.

**XDS-I—image exchange.** XDS for imaging has a variant known as XDS-I (Figure 2). Why? Imaging exams create data sets that are much larger than the text and discrete data that make up much of the medical record. The cost of storage and the bandwidth required to move the image data to a repository and then to a document consumer have been considered impediments to using the architecture of XDS. With XDS-I, instead of the images being moved to a repository, a listing of the available images, known as a key object selection (KOS), is placed in a repository when the exam is registered. When a document consumer wishes to retrieve the images, they would first retrieve the KOS. The KOS directs them to retrieve the images from the originating source, and it also lets the consumer know how many images to expect. For now, this is the way imaging data flows in IHE-enabled imaging exchanges. Whether this methodology will converge with basic XDS, as the cost of storage and bandwidth decreases, remains to be seen.

**XDS-related profiles.** IHE has developed several parallel exchange mechanisms, with XDS as the basis to address variant use cases. Cross-Enterprise Document Reliable Interchange (XDR) is a point-to-point mechanism without a formal health information exchange. XDR provides document interchange using a reliable messaging system. This mechanism permits direct document interchange between electronic health records, patient health records, and other health care IT systems in the absence of a document-sharing infrastructure such as an XDS registry and repositories.

The Cross-Community Access (XCA) profile is designed to allow independent XDS networks to communicate and exchange information with one another. One can begin to facilitate local, national, and international information exchange using these profiles as building blocks. A related profile, Cross-Enterprise Document Media Interchange, provides document interchange using a common file and directory structure over several standard media. This profile permits the patient to use physical media to carry medical documents, and the use of person-to-person e-mail to convey medical documents.

**Practical implications and implementation issues.** The IHE XDS profile is particularly relevant to the exchange of health care information. As noted earlier, it is part of a family of evolving health care IT interoperability and exchange methods intended to facilitate the secure and
confidential but transparent exchange of the patient’s health care information. Providers need this information to deliver high-quality care to their patients. In the United States, this notion of interoperability is emphasized by the federal government through the Health IT for Economic and Clinical Health Program. This program awards providers and health care enterprises financial incentives for implementing health IT and using it in a “meaningful” way.

**What to ask your IT staff and vendors.** Ask if the system you are about to purchase is compliant with the relevant IHE profiles. The entire IHE process is intended to streamline the purchase of IT solutions and make the process less expensive. As noted, compliance with IHE profiles should provide for an easily deployable solution without the need for expensive interfacing services. Plug-and-play solutions should be the expectation.

**USE OF CDs**

The opportunity for digital image information exchange was present from the advent of digital image acquisition. However, for many years, digital images were typically printed on film and reviewed and exchanged in an analog fashion (ie, nondigital images). Only as traditional film images (radiography) became digital did practices reach the point at which it became economically feasible to use digital media for image exchange. At the time (1990s), CDs were the most widely used portable digital media and were the obvious choice for exchanging digital images. With few viable alternatives, CDs rapidly replaced film as the exchange medium of choice. At one practice, the prevalence of CDs brought in by patients for medical care went from <5% to >95% in just 5 years [7]. Such an adoption curve is remarkably fast when compared to the rather slow adoption rate typical of major IT advances in health care.
Over the past 15 years, the adoption of CDs has been nearly complete, but changes in technology and complications with CD use have created pressure to develop alternatives. Over that time period, the file size of a typical cross-sectional imaging study has increased dramatically, largely owing to the advent of CT multi-detector technology and the growth in MR complexity and utilization. Exams using other modalities such as ultrasound have also seen increases in file size. As digital image archives become more established, the number of prior imaging examinations available on a patient also rises. Additionally, the number of examinations per CD has also increased, a recently noted trend. With the number of examinations and associated large file sizes, such data often rapidly approach the maximum capacity of a CD (around 750MB). This situation has led some providers to use digital video discs, which offer approximately 7 times more capacity than a CD.

The DICOM standard was an important enabler for the use of CDs as a universal portable digital image medium. DICOM specifies the way that each image should be stored and provides a directory system that allows a suitable imaging application to efficiently discover what is on the disc. The adoption rate of the DICOM standard for storing images on CD was always high—>90% around 2000—and has slowly crept up to >95% [7]. The use of the DICOM directory structure, however, is somewhat less prevalent—now at around 90% (unpublished data, Bradley J. Erickson, 6/5/2012). The IHE organization has further elaborated how the DICOM standard is best implemented, resulting in the portable data for imaging specification (see http://www.ihe.net/technical_framework/upload/ihe-rad_tf_supp_pdi_extensions_2009-06-21.pdf).

Switching to digital video discs addresses the capacity problem but not the more fundamental issue of using physical media to transfer images. Having to share a physical disc among health care providers creates many important challenges. First, although passing a disc from one health care provider to the next, or having the patient carry it, may be feasible in smaller facilities, these methods do not work well in more-complex clinical scenarios.

Patients with intricate problems typically see multiple providers, creating contention for access to the single imaging disc that might be important in decision making. Additionally, in the film era, film loss was not uncommon. This scenario is possible for a disc, and losing all of a patient’s examinations would have an even greater impact than losing film from a single exam. In addition, handling the disc risks physical damage that

**Fig 2.** Cross-Enterprise Document Sharing for Imaging Diagram (reprinted with permission from Integrating the Healthcare Enterprise cochair David S. Mendelson, MD). ITI = IT infrastructure; MTOM/XOP = message transmission optimization mechanism/XML-binary optimized packaging; RAD = naming convention for IHE transactions; WADO = web access to DICOM objects; XDS-I = cross-enterprise document sharing for Imaging.

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SSAE = Statement on standards for attestation engagements.
might make the disc unreadable. For these reasons, sharing the disc among health care providers is not an optimal solution.

An alternative to sharing the physical CD is to import the CD contents into the local image viewing system, most commonly the PACS. Until recently, most PACSs did not have efficient tools to import CDs. Now, this option is more widely available and often implemented in a way described by the IHE. IHE provides for 2 main variants of image “import reconciliation workflow (IRWF)”—one that is “scheduled” and one that is “unscheduled.” The main difference is that in a scheduled workflow, the system creates an order before the import is performed, which potentially allows information (such as the type of examination) to be included in the text description presented by the image viewing system. In the unscheduled scenario, the images are imported, but no additional information about the study is provided.

Importing the images into the viewing system allows enterprise-wide access to images, addressing the problem of making a single disc available to all health care providers. In addition, this solution addresses another important problem: many discs include simple viewing software, but those without it are not useable because DICOM viewing support is not included in any major institutional imaging operating system. Including a viewer on the disc addresses that problem but creates a new one—users need to be able to use the viewing software to view images. No such software package is regarded as universally easy to use. Each particular viewer has its fans and detractors, and each seems to provide a slightly different array of viewing tools presented in nonstandard graphical user interfaces.

IHE has created a Basic Image Review (BIR) profile to help increase the similarity of user interfaces on viewing packages to reduce the problems of unfamiliarity. However, if one set of images is in one viewing application, and the follow-up examination has to be viewed in another application (possibly even on a different computer platform), comparing imaging time points is more challenging. Furthermore, notes or annotations created during image review may not be saved to the CD. Finally, compliance with HIPAA is easier to maintain when a CD is viewed from within a PACS than with a CD viewer.

Another important challenge that is not widely recognized is the low data integrity of CDs. Data integrity has physical and logistical components. When the physical integrity of the CD is degraded (such as by scratching or bending), it can become unreadable. A more insidious integrity issue is whether the data on the CD truly belong to the specified patient. In one recent report, it was found that 1% of CDs contained information that was derived from multiple patients, and another 1% contained studies from a single patient that was not the intended patient. In many such cases, the “other” individual had a nearly identical name or medical record number, and the mistake was likely due to operator error during CD creation.

Images contained on CDs are considered patient medical information just like medical images on PACS or nonimaging medical data. Often, HIPAA applicability for CDs is unclear because, for example, the data may have been generated at a different facility, and the patient may have served as the conduit for the transfer. Just as verbal comments from patients to health care providers are protected by HIPAA, handling CDs in a way that protects patient privacy is prudent. However, CD-based viewing applications are not designed to truly authenticate and record actions; thus, creating proper HIPAA logs in this way is virtually impossible. Given this difficulty, data that are important enough to guide medical decision making should be imported and viewed using the local viewing software to assure confidentiality and HIPAA compliance. Once import of images has been accomplished, the CD should be returned to the patient as quickly as possible.

Finally, a substantial cost is incurred in transferring images by CD. The medium itself is cheap—typically a fraction of a dollar per CD. However, the cost to produce a CD is rather high, although determining the true costs is hard. A survey of several institutions indicates that the labor and system cost is in the range of $15 to $25 per CD. The cost is higher when images must be produced in an ad hoc fashion, which often requires a query for a specific examination from the image archive, having a person wait while the images are written onto the CD, and then creating a mailer and mailing the CD. The charge to the patient for creating a CD varies from $0 for the first copy to >$40 per CD for additional copies.

**IMAGE SHARING ON THE CLOUD**

**Benefits of Cloud-Based Imaging Platforms**
The benefits of cloud-based imaging sharing platforms are becoming clear to stakeholders across the entire health care enterprise. Cloud-based imaging creates new value by making images easily accessible for radiologists, referring physicians, and most importantly, patients. Cloud-based image sharing ensures increased availability of imaging studies in space and time, geographically, and among multiple health care providers at the point of care.

Key benefits include [5]:
- Increased quality of care
- Reduced costs
- Reduced hassle of duplicative imaging examinations
- Potentially decreased duplicative radiation exposure

By contrast with sharing images through physical media, such as hard copy or CD, cloud-based image
sharing enables files to be digitally transmitted in minutes, or even less time. Furthermore, elimination of physical media reduces cost and potential errors from lost or corrupted data. Speed of image sharing reduces the chance of patient care being negatively affected by delayed diagnosis or treatment. Opportunities to reduce radiation dose occur when cloud-based image-sharing tools can avoid unnecessary repetition of nuclear medicine, X-ray, or CT imaging, particularly for patients who are transferred between institutions or receive care at multiple facilities. Cloud-based image sharing represents a major evolutionary step in health care informatics, enabling sending, sharing, and accessing of images from multiple disparate facilities. When they are properly implemented, cloud-based solutions can safely and securely provide images and reports.

Suggested Strategy for Cloud-Based Image-Sharing Vendor Selection Request for Proposal

Each health care facility or physician group will have a unique set of use cases and needs. Given the numerous cloud-based image-sharing solutions currently on the market, select a solution may be a daunting task, but key specification categories can be used to review and select the appropriate solution. Such specifications include capabilities related to integration with existing systems, image storage, image distribution/sharing, image viewing, and pricing models (Table 1).

DICOM and HL7 Integration

Significant efforts in the health care IT community are under way to improve the way computer systems share medical information. Specifically, one keystone effort is the IHE initiative, which aims to coordinate the use of established standards. Systems that use established standards such as DICOM and HL7 will be easier to integrate and implement in a health care facility. DICOM routing, push, and query/retrieve (pull) features are essential components that should be supported in a cloud-based image-sharing solution. Integration features need to support the following potential issues and requirements:

- Medical record number/patient identifier reconciliation
- XML (Extensible markup language)/HL7 communication standards
- Autorouting of studies to PACS or another image archive via cloud-based solutions
- Full DICOM routing support (push/pull).

Data Security and HIPAA Compliance

When evaluating systems designed to transfer digital data, particularly health care data, a critical question to ask of any vendor is: “Where are the images physically hosted?” A high-security, HIPAA-compliant data hosting center is essential. Data centers used by vendors need to meet strict standards for data protection in order to be HIPAA certified. These standards include specific onsite training for personnel. In addition, data centers must be subject to government audits by HIPAA inspectors. When selecting a vendor, one should inquire about prior audits and HIPAA certification of data centers used to store medical imaging data. A solution that is both secure and HIPAA compliant must have the following features: (1) identification and authentication; (2) authorized privileges; (3) access control; (4) confidentiality; (5) integrity of data; and (6) accountability and audit trails.

Image Viewer

Several methods of viewing medical images have been developed. Over the years, technologies have used methods including, but not limited to, Java applets, thin client downloadable scripts, Adobe Flash, and ActiveX-based technologies. Each of these is limited in that it may work on only specific platforms, not all. One preferable option for the review of images for a cloud-based solution is the “zero-footprint viewer.” This latest development requires no software to download and is not limited by device or hardware specifications. From an IT security perspective, these features are highly desirable; many sites do not permit the installation of applications, including viewers, on front-end computers.

In today’s health care IT enterprise, zero-footprint medical image viewers enable access to data on any device in a completely seamless manner. For example, tablets, smartphones, mobile devices, and any platform PC (Mac, Windows) are compatible with true zero-footprint viewers. Zero-footprint viewers are faster and utilize the built-in web browser plugins and technologies to enable viewing with minimal installation or software “footprints.” One should be aware that zero-footprint viewers often come with limitations in functionality that are often acceptable to the nonradiologist audience or for the specific purpose that the zero-footprint viewer is intended.

Pricing Models

General pricing models have been created for cloud-based image-sharing solutions. Although in general any relationship with a vendor can be customized, both fixed/subscription models and elastic (resource-based, pay-as-you-use) models are available. Typically, fixed and subscription pricing tend to be more traditional and may be renewable at fixed time intervals—annually, for example. A resource-based usage model is a more novel and recent pricing model. In this elastic model, users pay per unit hour of use, central processing unit cycles, or bandwidth consumption.

Security

Although significant benefits can be gained by delegating imaging data management to a cloud vendor, a major limitation is the risk burden that a health care facility carries when relinquishing direct control of imaging data. Placing protected health information on the
cloud requires significant due diligence regarding a cloud vendor’s security and privacy capabilities. Vulnerabilities or security-compromise events may result in risk management challenges and liability issues that must be handled promptly. Data breaches can be costly owing to downstream litigation, harm to the health care facility’s reputation, and government-based fines. The cloud vendor should have the ability to encrypt and back up all data. Furthermore, the cloud vendor should allow any client to conduct regular audits.

**HIPAA Compliance**

Regulatory issues related to cloud computing for health care enterprises need to be considered. Specifically, establishing a relationship/contract with a cloud vendor for the transfer, storage, or management of any kind of health care data, including medical images, requires compliance with HIPAA and the Health IT for Economic and Clinical Health Act.

**Bandwidth Requirements**

Cloud-based services require significant investment in network resources and Internet bandwidth. In the noncloud health care enterprise, users are accustomed to the advantages of a high-speed local area network. In an environment without such a network, namely a cloud-based environment, users may experience performance or latency issues resulting in potential customer satisfaction issues. If the data center(s) are at geographically dispersed multiple sites or if Internet-related outages occur, the network speed and, ultimately, access to mission-critical medical imaging data may be affected. As a result, to limit exposure to the risk of bandwidth compromises, testing of cloud-based vendors and solutions are requisite. The cloud infrastructure must be stress-tested to ensure that the health care data stored is accessible, minimizing bandwidth bottlenecks. If bandwidth issues occur during the testing phase, the health care facility should work with the vendor to resolve them prior to deployment of a cloud-based image-sharing solution.

**IMAGE SHARING IN RESEARCH**

Image sharing in context with (multicenter) imaging-based research presents many challenges similar to those in the clinical use case, and some unique ones. Imaging has long been a means to provide objective data on patients; one example is study inclusion of therapy-response assessment. In addition, research conducted at a single site is well recognized as being important but potentially not generalizable. Given this limitation, sharing of images is essential for high-quality and multicenter collaborative science. Compared with the clinical environment, image sharing in the research environment has important and unique requirements. For many research protocols, adherence to a predetermined acquisition protocol is essential. In cases in which a specific window of time is available for acquiring images (eg, one requests imaging a certain number of days after an intervention), rapid transfer of images is required. But even in these specific scenarios when rapid transfer is necessary, validation of protocol adherence must also be rapidly determined. In most cases, automatically determining if the technical aspects of the acquisition have been adhered to can be accomplished by examining the associated DICOM metadata (eg, slice thickness, milliamperes, repetition time/echo delay time). Assessment of artifacts such as motion often requires human quality evaluation. Technologic solutions ideally enable rapid and secure transfer of properly anonymized data to a central site where technical and practical image acceptability can be determined rapidly, so that proper responses can be made (such as rescanning the patient).

In the research environment, reports are usually not required and might even be a liability because anonymizing report contents may be much more difficult and because blinded reader assessment may be required as part of the research protocol. Thus, another unique demand of research is removal of portions of images that might have data (not only the header but also information burned into the pixels of the image, in case of secondary screen captures). This challenge can be formidable but fortunately is becoming less common. Libraries are being built that document which devices may “burn” information into images and the location of such burned-in information, allowing automated deletion of that information.

As with clinical image sharing, the options for research image sharing include exchange of images using physical media such as CDs, as well as electronic transfer. The research community has a longer history of creating image-transfer methods, and several open source and proprietary tools are available for research image exchange. Some sources utilize encryption, allowing use of public networks, and others require virtual private networks or even physically private networks. Nearly all such transfer methods require unique software to transmit the images, and as no standard has been established for research image exchange, each method utilizes its own software. The result is that large imaging centers often have to support many different image-transfer software platforms for various clinical trials. An example for a solution built to facilitate multicenter imaging research is the ACR Transfer of Images and Data (TRIAD) System, which has been used extensively in multicenter trials of the ACR Imaging Network (see https://triad.acr.org/).

Security is an important consideration in research image sharing, but the issues are slightly different than they are in clinical image sharing. Removal of patient-identifying information before images are transferred to a researcher, whether for internal or external use, is commonplace and expected by most institutional review boards. Given this expectation, random discovery of such information on research-related images.
is of less concern than it is with clinical images. Instead, investigators may worry that someone else might obtain unauthorized access to the data and gain knowledge of intellectual property unique to the research project. Although this risk is likely small, it is real and important to consider in designing the security model.

**TAKE-HOME POINTS**

- CDs will be replaced by Internet exchange of images and reports. The transition has started.
- Interoperability is a major focus of health care IT.
- Standards are cardinal to the easy, secure, and confidential exchange of health care information, including imaging exams.

**REFERENCES**