Consolidated Imaging: Implementing a Regional Health Information Exchange System for Radiology in Southern Maine

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Abstract

The traditional, film-based radiology system presents serious limitations for patient care. These include forcing clinicians to make decisions based on information that is often less than optimal and making transfers of films and prior studies to other facilities more complicated than they need to be. Picture Archiving and Communication Systems (PACS) address these issues by allowing for acquisition, storage, display, and communication (e.g., transportation) of images in a digital format. Although PACS has been shown to improve patient care, many rural health care organizations have found obtaining these systems cost-prohibitive. The Consolidating Imaging Initiative (CI-PACS) in Maine provides an alternative way to offer this technology to rural hospitals. Through CI-PACS, a tertiary care hospital and its health care system have implemented a shared, standards-based, interoperable PACS in two rural hospitals (one belonging to the larger health system and one not). In this article, we discuss how the regional system works, and how it will be sustained. We also highlight the unique challenges associated with implementing a regional system.

Introduction

Over the last few years, the health care system has increasingly focused on obtaining health information technology (HIT), especially electronic medical records (EMRs). Although the number of health care providers adopting HIT has increased, there continue to be significant barriers and challenges to acquiring this technology.[1, 2, 3] Hospitals identify cost as the major barrier to adopting HIT, including initial and ongoing costs of maintaining the systems.[2] Other important challenges include issues with interoperability with other systems, medical staff support and usage of HIT, difficulty building a strong business case for adoption, availability of IT staff, and privacy and security of patient information.[1, 2, 3]

Rural health care providers have many of the same challenges as urban providers, but these challenges can affect rural providers to a greater extent. In rural settings, where salaries are lower, hospitals and other providers have difficulty attracting and retaining IT staff to implement and maintain HIT. Rural physicians may be less technologically savvy and more resistant to HIT adoption. Rural providers also may face unique challenges. For instance, they may find it more difficult to obtain needed network bandwidth or may face higher transmission costs than their urban counterparts.[2, 4]

Health information exchange (HIE) allows different health information systems to share clinical information electronically among health care organizations. Therefore, HIE helps health care providers access and retrieve patient information across the continuum of care.[5] With the development of Picture Archiving and Communications Systems (PACS), health care providers have a new opportunity to exchange radiology information across organizations. PACS is a digital radiology system that acquires, stores, displays, and communicates (transports) radiology images in a digital format.[6] Many rural hospitals want to move to a filmless system, but the startup and ongoing costs and the technologic challenges of maintaining large and complex information systems are onerous. Most rural hospitals have considered filmless systems and recognize that they will ultimately be necessary, but few believe that these challenges are currently surmountable. Participating in a shared PACS not only allows rural hospitals to obtain a PACS, but may provide them with additional benefits beyond purchasing their own stand alone PACS.[7, 8]

Sharing a PACS among multiple providers is not necessarily a new concept. However, most attempts involve organizations that all belong to the same health system and share the same technology infrastructure, patient identifiers, information systems, and support staff. They also share the same organizational structure, which reduces or even eliminates issues of trust, cooperation, persistence, and dedication to fundamental change. On the other hand, a shared PACS must integrate multiple organizations in order to make each hospital's system compatible with the shared system. They also must gain the trust and cooperation of independent radiologists.

In February 2001, MaineHealth, Maine Medical Center (MMC), and other health care providers developed the Consolidated Imaging Initiative (CI-PACS) to explore ways to allow multiple organizations to archive radiology images through MMC's PACS and to retrieve and display those images throughout each organization's clinical enterprise. With the support of an Agency for Healthcare Research and Quality (AHRQ) HIT Implementation Grant, the CI-PACS began implementing a shared system with two rural hospitals, Franklin Memorial Hospital (FMH) and Miles Memorial Hospital (MMH).

Prior to implementation, the involved hospitals anticipated three major benefits: one, cost savings; two, improved quality of care; and three, improved access to radiologists. By eliminating film, film storage needs, and the need for an archive, the two rural hospitals expected to save money in the long term. MMC could also benefit by distributing their costs for PACS across multiple organizations. With a shared system, each hospital would have access to the other hospitals' radiology information. Having access to relevant prior images and reports has been shown to improve the interpretation of radiology exams.[7, 8]

Lastly, many rural hospitals have difficulty recruiting and retaining radiologists. They also require a limited amount of a radiologist's time. Since MMC employs the radiologists of Spectrum Medical Group, an independent physician group, if one of the rural hospitals were to lose its radiologist, they would have the potential to hire someone from the group. Miles Memorial Hospital, which already hired a Spectrum radiologist, expected CI-PACS to help make coverage for nights, weekends, and vacations more efficient. Without the shared PACS, these

radiologists would have to travel about an hour to Miles Memorial Hospital. However, with the PACS, the radiologists at Spectrum could remain in Portland to review the exams.

As part of the AHRQ grant, an evaluation was conducted. The evaluation focused on two objectives: documenting the implementation process and lessons learned and assessing the impact of a shared PACS on cost and quality.

In this paper, we focus on the implementation process and lessons that were learned from the project. We describe the organizations involved and the phases of implementing a shared PACS. We then discuss the implementation challenges faced by the rural hospitals and the benefits that participants perceived as being realized by these hospitals.

Creating a Shared PACS in Maine

Organizations Involved

Figure 1 provides a map that identifies each organization involved and the distance of the two rural hospitals from MaineHealth, Maine Medical Center, and Spectrum Medical Group (all located in Portland). Maine is a large, mostly rural State. As illustrated in Figure 1, the hospitals participating in CI-PACS are separated by considerable distance. Because MMC is Maine's largest tertiary system, these and other hospitals refer many of their patients to MMC.

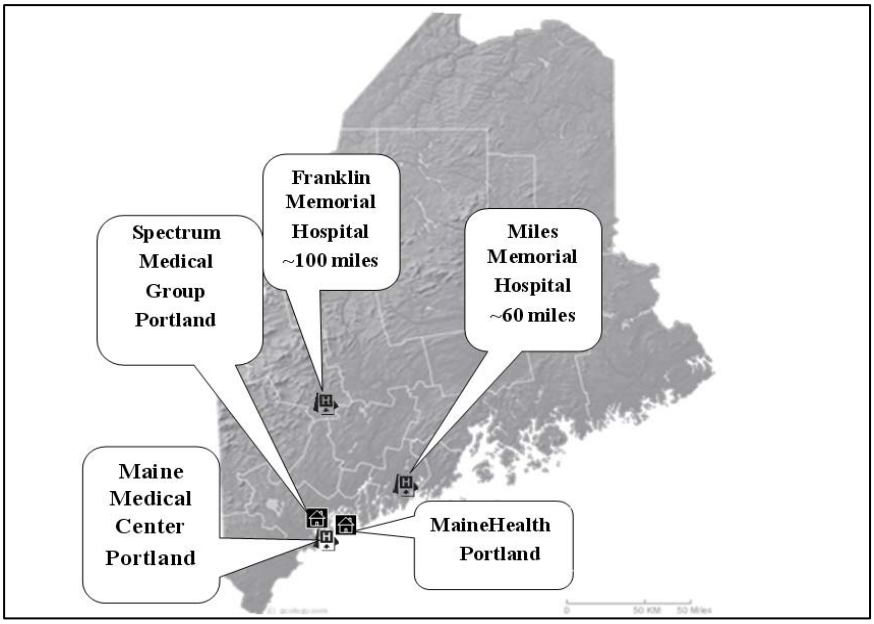

Figure 1. Location of organizations involved in CI-PACS

MaineHealth. MaineHealth is a not-for-profit integrated health care delivery system that serves approximately three-quarters of the State's population (1.2 million). MaineHealth provided the leadership to develop the partnerships needed to implement CI-PACS. Members of this system, including MMC and Miles Memorial Hospital (MMH), are owned by MaineHealth, while affiliated organizations are independently owned. MaineHealth offers a wide array of benefits and services, which are voluntary for members and affiliates.

Maine Medical Center. MMC, owned by MaineHealth, is the largest hospital in Maine, with 600 beds. MMC acts as a Level 1 trauma center and a tertiary referral and teaching hospital. The department of radiology performs over 180,000 exams per year and has 25 diagnostic radiologists. These radiologists are members of the Spectrum Medical Group, described later.

MMC's radiology informatics team, located within the radiology department, has developed expertise in radiology workflow and integration of radiology systems. They managed and carried out the implementation of CI-PACS at the two rural hospitals.

Miles Memorial Hospital (MMH). MMH, a MaineHealth member, has 46 beds, including 22 medical/surgical, 8 intensive care, 8 day surgery, and 8 obstetrical beds. Approximately 82 percent of the hospital's revenues come from Medicare and Medicaid, forcing the hospital to depend on fundraising and grants to purchase new equipment or systems. The radiology department has only one full-time radiologist, who is contracted from Spectrum Medical Group in Portland. They offer CT, ultrasound, mammography, x-ray, and mobile MRI services. The majority of their referrals are sent to MMC.

Franklin Memorial Hospital (FMH). FMH is not a MaineHealth member or affiliate. The hospital has 70 beds and serves approximately 40,000 individuals in 23 predominately rural communities in northwestern Maine. FMH has developed its own health network, which includes four other organizations: a behavioral health provider, a community public health coalition, a multi-specialty group practice, and a physician hospital organization. The radiology department is staffed by two radiologists who are independently employed, representing 1.5 full-time equivalents. They currently perform 42,000 images a year. FMH refers its patients to MMC in Portland and to Central Maine Medical Center in Lewiston.

Spectrum Medical Group. Spectrum Medical Group (Spectrum) is Maine's largest physician-owned and -led multi-specialty practice. The group includes over 140 board-certified or eligible providers, including radiologists. These radiologists perform over 600,000 diagnostic exams or interventions each year and provide subspecialty expertise. Spectrum designated 25 percent of a radiologist's time to work on the implementation of CI-PACS. This work included optimizing the clinical work and service environment, streamlining radiologists' workflow, enhancing the function and usefulness of the PACS, and working with the other hospitals' staff while implementing CI-PACS. Spectrum also contributed $100,000 for a diagnostic workstation at MMH, which allowed the radiologist to perform softcopy interpretations for CT, MRI, and ultrasound.

Functioning of the System

Through CI-PACS, MMC stores all images taken at MMH and FMH on the MMC servers. Storing images on a single server allows the hospitals to access their own and other organizations' images through wide-area network (WAN) connections to MMC and eliminates the need for each hospital to have its own server. MMC also implements and maintains the PACS at each facility, provides IT support, and installs upgrades. The rural hospitals pay for new radiology equipment (e.g., computed radiography), network connections, and data transmission costs. Although the AHRQ implementation grant provided the funding needed to buy equipment and install the system in the hospitals, MaineHealth and MMC have created a way to sustain the system, using a per-exam fee schedule to cover MMC's costs.

Implementing CI-PACS: The Major Phases

The implementation process consisted of seven phases, with each being critical to success. They are described in the approximate order in which they were accomplished, but some phases overlapped. Each phase description focuses on the high-level tasks.

Phase 1: Pre-implementation preparation. A CI-PACS management team was created to develop implementation plans and oversee the implementation process. The management team consisted of radiology personnel from MMH, FMH, and Spectrum and the Director of Radiology Informatics from MMC. Administrative, clinical, and information systems staff joined the team when needed.

The management team first conducted a workflow analysis, which assessed the current and future states of workflow in each radiology department. Conducting a workflow analysis was essential in determining how best to implement CI-PACS at each hospital. While the system can typically adjust to differences in workflow, some differences cannot be addressed without changing the workflow process. Therefore, this analysis also identified when workflow needed to be changed to fit the system.

Also during this phase, the team assessed DICOM (Digital Imaging and Communications in Medicine) conformance and infrastructure needs. DICOM is an application network protocol that allows for the transmission of radiology images. A DICOM standard was designed to ensure the interoperability of radiology systems. For DICOM conformance, the team evaluated the conformance of each modality (e.g., CT, MRI) to determine the level of interoperability of MMH's and FMH's modalities with MMC's PACS. Non-DICOM-compliant systems required unique solutions to make them conform to the system.

To implement CI-PACS, FMH and MMH needed to upgrade their local area networks (LANs) and WANs. During the pre-implementation phase, the team determined the time needed to obtain the network bandwidth, connectivity, and quality of service enhancements. Obtaining network connectivity and required network bandwidth has often been difficult for rural communities. Infrastructure changes included designing reading room configurations and determining equipment and lighting requirements.

Lastly, the team created a training plan to encompass both functional use of CI-PACS workstations and the changes in workflow. The training plan focused on radiology staff and other clinicians to ensure optimal usage and image review frequency. The team used a train-the-trainer model, with MMC's radiology informatics staff training one or two "super users" at each hospital and then having these "super users" train their own staff. Each hospital used group training sessions, while FMH also used one-on-one training as new parts of CI-PACS were implemented.

Phase 2: Establish network connectivity. Ensuring adequate network bandwidth represented the key technologic challenge during implementation. Only FMH needed to establish a WAN connection, but both hospitals had to obtain the necessary bandwidth. Although the hospitals and management team worked closely with their community's telecommunications provider to establish these connections, obtaining the necessary bandwidth took both hospitals at least a

year. The costs of WAN for MMH and FMH have been $30,000 and $50,000 per year, respectively.

Phase 3: Demographics/radiology order flow. The PACS-Radiology Information System (RIS) interface provides the CI-PACS with patient demographic and radiology order information. A RIS is a computer-based system that allows a radiology department to store and maintain patient radiology data and images. Most systems provide patient registration, appointment scheduling, patient tracking, results entry, and reports. The interface between the PACS and RIS serves a number of additional functions, including:

- Linking PACS imaging information and Hospital Information Systems (HIS)/RIS clinical information.
- Connecting all studies for a given patient.
- Providing the necessary order information to enable automatic retrieval of relevant prior exams.
- Updating patient demographics, when the information is updated or changed.
- Associating radiology results in the RIS to the images archived in PACS.
- Providing new and prior reports to clinicians via the PACS and Web-based access.
- Providing the link between the digital dictation system and PACS.

The accession number or exam identifier allows the CI-PACS to associate all images for a particular study to an order and all its associated patient and clinical information in the HIS and RIS. Without a valid accession number, the validation process—which ensures that all human data entry errors are corrected before the study is archived—cannot occur. Therefore, the images would note be available for the radiologist to interpret or for clinical distribution.

An important decision that each hospital had to make was how to integrate CI-PACS with MMH's and FMH's Meditech systems. Meditech is a vendor that provides HIS and RIS products. The order information could be manually entered in CI-PACS through the Cerner RIS (MMC's RIS), or an interface could be developed between the MMH and FMH Meditech systems and the MMC RIS. Interfaces also needed to be created to connect result reporting and transcription. Ultimately, both hospitals chose to keep their own HIS and RIS, requiring the creation of interfaces.

Phase 4: Computed radiography implementation. Both rural hospitals installed a computed radiography (CR) unit to enable direct digital capture, storage, and display of images. CR provides physicians and radiologists with images ready for interpretation almost immediately after the technician validates that the exam was performed correctly. To provide some redundancy should the CR unit fail, the hospitals implemented a high-volume and a low-volume unit.

Phase 5: Modality connectivity and digital archiving. Based on pre-implementation analysis, modality connectivity required upgrading each modality, as needed, to ensure full DICOM compliance. The implementation team also provided each hospital with diagnostic-level digitizers, which allow for the conversion of films to digital images. Once network connectivity

was established and patient demographic and radiology information was available in the MMC RIS, images were ready to be archived. By archiving images, the images can be stored, routed, prefetched, and softcopy reviewed. Also during this phase, the workflow re-engineering process occurred, and training began with radiology and clinical staff.

Phase 6: Diagnostic softcopy reading. The activation of softcopy reading on a PACS workstation depended on several steps, including:

- Installation of radiology workstation(s).
- Configuration of the CI-PACS to forward studies to the local workstation.
- Creation and customization of each user's account.
- Installation of appropriate digital dictation equipment and interfaces.
- Training all radiologists on the use of CI-PACS workstations.
- Training other radiology staff in new soft copy reading workflow.

At this point, only radiologists were able to view images. Web access, implemented in the final phase, provided access to other clinicians.

Phase 7: Web access rollout. Implementing Web-based access to digital images expanded the softcopy review to additional clinical areas. Before full implementation of Web-based access, the implementation team needed to demonstrate high levels of system performance and reliability and completion of the hospital network implementation. Softcopy access was provided through Agfa Corporation's Web1000™ tabletop processor, using Web-based review stations positioned in the emergency department and other high-use clinical areas. These workstations provided clinicians with diagnostic-quality images and image manipulation. In addition, the system allowed remote sites and physicians' offices access to images as long as they had a connection into the hospital's CI-PACS network. With these connections, the implementation team hoped that FMH and MMH could reduce their reliance on hardcopy films by at least 90 percent, providing cost savings that could be used to help sustain the CI-PACS implementation.

Implementation Challenges

Information on challenges was obtained through onsite interviews with hospital management, radiology staff, and IT staff. These interviews focused on the planning and implementation process, satisfaction with the process, challenges and how they were overcome, and lessons learned. Our discussion is focused on the challenges faced by the two rural hospitals. The challenges are presented in three major categories: technical, inter-organizational, and human resources and training.

Technical challenges. There were several technical challenges during the implementation of the shared PACS, including WAN connections, higher transmission costs, responsiveness from Agfa and MMC, and creating a master patient identifier. Both rural hospitals had significant problems obtaining their WAN connections and adequate bandwidth from their local telecommunications provider. They each waited at least a year for these needs to be met. However, since the study began, the ability of rural communities to obtain these connections has improved, potentially making it less of a problem in the future. FMH and MMH also paid higher transmission costs per

year than urban hospitals, with FMH paying $50,000 per year, and MMH paying $30,000 per year. Although it is too early to assess results, MMC and the rural hospitals expected that cost savings obtained from reducing the need for film-based images would help to cover these transmission costs. Similar to the WAN connectivity problem, transmission costs have decreased over the last 3 years, making this less of an issue. Some staff felt that IT and system support were not as quick or effective as they expected. One hospital had to wait 2 weeks for the vendor, Agfa, to respond to a problem.

MMC faced a significant challenge in developing a master patient identifier across the organizations participating in CI-PACS. With separate patient identifiers for each hospital, it was essential to develop an effective approach to sharing clinical and administrative data from these disparate systems. MaineHealth created a master patient index which conducts a behind-the-scenes matching of the same patient, using demographic information. However, the system does not work perfectly, due to errors in the data and people changing their names or moving. In these situations, a person has to manually process these matches and might need to make phone calls to verify that the records are for the same person. The manual process often results in a delay in accessing relevant prior exams when they are needed.

Interorganizational challenges. There were several inter-organizational challenges during the CI-PACS implementation, including differences in knowledge and differences in workflow. Rural and urban hospitals function very differently. Urban hospital staff are highly specialized, whereas rural hospital staff tend to be generalists. Although the management team conducted a workflow analysis within each radiology department, some rural staff felt the implementation team did not understand how their radiology department worked. While rural hospitals have a strong understanding of how their hospital and radiology department operate, they might not have much expertise in PACS. On the other hand, MMC has significant expertise in PACS but might know very little about how rural hospitals work. Given this problem, rural staff found it difficult to communicate what they wanted in a PACS, while urban implementation staff had difficulty determining what PACS components would work best for each rural hospital.

In addition, unexpected differences in workflow could not be changed at FMH. Prior to PACS, the transcription process at FMH identified and placed urgent or emergency cases at the top of the list. For these cases, transcriptionists were provided information on whom to call immediately after the report was completed. On the other hand, the transcription system used by MMC placed urgent or emergency cases at the top of the list but did not identify them as urgent. Therefore, they appeared just as the next report to transcribe, and transcriptionists did not know to rush a particular case. The system also did not include information about who to contact when the report was completed. Initially, FMH tried MMC's transcription system but decided that they could not change this portion of their workflow. To resolve this problem, MMC's IT staff is creating new interfaces to ensure that the different transcription system will work under CI-PACS. Until completed, FMH's radiology reports are unavailable on CI-PACS.

Human resources and training challenges. The two rural hospitals approached IT support and project management in different ways. One hospital decided they needed an IT support person onsite. Fortunately, they had a radiology technician who also had an IT background. The hospital felt that having this person allowed them to look out for their hospital's interests, assist in project

management, and address day-to-day issues during PACS implementation. The other hospital did not hire its own IT support staff or a project manager. Instead, they relied on an IT staff person provided by MaineHealth, which they had to share with another rural hospital. The director of radiology took on the responsibility of managing the radiology department and the implementation process. In retrospect, the director believes that the implementation process would have gone more smoothly if they had hired a staff member dedicated to the CI-PACS implementation.

They also approached training and obtaining clinician buy-in differently. One hospital involved their radiologists, physicians, and others in the planning phase. By doing this, they were able to identify physician champions, making it easier to get buy-in from other clinicians in the hospital. The other hospital did not take this approach and found it harder to get physicians to buy-in to the new system. At one hospital, they not only informed staff before a new phase would be implemented, they also provided group training and one-on-one training the first time a clinician dealt with the new technology. The other hospital provided only group training, possibly making it harder for staff to learn the new technology and potentially affecting staff's willingness and comfort with using the system.

Perceived Impact of Shared PACS

The hospitals involved in CI-PACS anticipated that the shared PACS would bring additional benefits over a stand-alone PACS, including greater access to relevant prior exams, cost savings, and assistance with radiology coverage. As part of the evaluation of CI-PACS, we wanted to know whether hospital staff actually felt they had achieved these benefits. Through interviews with hospital management and radiology and IT staff, we found that overall, the staff at both rural hospitals felt that the shared PACS had achieved the expected impact. Radiologists found that they had improved access to relevant prior exams, allowing them to base their diagnoses on better information. However, a few staff thought the drawbacks of a shared system did not outweigh its benefits. They stated that the shared PACS was slower than a stand-alone PACS because they needed to transmit images over long distances, while they had only a small percent of cases where they needed a relevant prior image from another organization. One staff member suggested that being able to make hospitals' different stand-alone systems interoperable would be more effective and efficient.

While the hospitals have not had enough time to assess the actual cost savings due to CI-PACS, all staff expected to save money over the long term. In addition, as more organizations have come into CI-PACS, the per-exam fee has decreased, making it more likely that cost savings will increase over time. The only concern among the staff was how they would cover the transmission costs after the grant period was over.

MMH has a radiologist from the Spectrum Medical Group, which means other Spectrum radiologists can assist him. This radiologist found that if he became too busy or could not come to work, Spectrum radiologists could provide the hospital coverage by reading exams remotely. This not only benefited MMH, it also allowed Spectrum radiologists to provide coverage more efficiently, not needing to drive to MMH. Although not used to its full potential, both hospitals found consultation from other radiologists, especially subspecialty radiologists, to be an important benefit from CI-PACS. With these consultations, they could determine whether a

patient needed to be transferred to MMC or another facility and to confer with another radiologist in difficult cases.

Conclusion

The Consolidated Imaging Initiative developed by MaineHealth and Maine Medical Center can provide other rural and urban hospitals with a blueprint for developing systems within their own communities. Most staff at the rural hospitals thought the implementation process went well overall and was probably easier and faster than if they had implemented a stand-alone PACS. They have already perceived an impact of the shared system on their radiology departments, especially for access to relevant priors from other organizations.

However, there were technical, interorganizational, and human resources and training problems during the implementation project. Some of the technical problems have been easily resolved, while others will take more time. Over the last 3 years, rural communities in Maine have attained improved access to needed network bandwidth and lower transmission costs, making this less of a problem for future projects. Shared PACS requires either a master patient identifier or a manual process of matching exams to patients with different identifiers at each organization. With the development of the Enterprise Master Patient Identifier by MaineHealth and MMC, other organizations might find creating a unique patient identifier a little easier. A national patient identifier could virtually eliminate the problem, but there are still privacy and security concerns with this approach.

The inter-organizational problems related to differences in knowledge and workflow could be resolved in several ways:

1. The rural hospital could hire an IT person with experience in rural radiology systems and PACS.
2. The urban hospital could hire an individual or consultant with knowledge about how rural hospitals work.

At FMH, a radiology technician with a background in IT was already on staff, which made the implementation process easier at that hospital. Rural hospitals considering a shared approach should consider hiring an IT person with experience in PACS or rural radiology systems. Unfortunately, this approach might be difficult for rural hospitals, since they frequently have problems recruiting and retaining IT staff, especially more specialized IT staff members. A more realistic approach might be to have the urban hospital hire a consultant with knowledge about how rural hospitals work. The consultant could act as a liaison between the rural and urban hospitals to better communicate workflow issues and other needs.

The availability of human resources and the need for training approaches were also identified as challenges during the implementation process. Rural hospitals might improve the implementation process by hiring their own IT support staff, even if part time, and a project manager to deal with day-to-day implementation issues. The IT support position, especially one with rural hospital experience, would ensure a smoother implementation and more effective communication between the urban and rural hospitals. The project manager would prevent the

director of radiology from being overwhelmed. Radiology directors should also involve physicians and other clinicians that need to use the system in the planning phase and identify physician champions to help convince reluctant physicians of the benefits to their practices of a shared PACS.

Participating in a shared or regional PACS might provide rural providers with an alternative approach to acquiring a filmless radiology system. Many rural hospitals and providers cannot afford or support a stand alone PACS. The Consolidated Imaging Initiative brought two rural hospitals access to PACS and provided potential cost savings, improved access to relevant priors from other organizations, and more secure access to radiologists.

Acknowledgments

We appreciate the cooperation of hospital managers and other staff at MMC, FMH, and MMH throughout this project. The Agency for Healthcare Research and Quality (AHRQ) provided funding for the implementation of the Consolidated Imaging Initiative and the evaluation. The conclusions and opinions expressed in this paper are the authors' and no endorsement by the University of Southern Maine, the Maine Medical Center, or the funding source is intended or should be inferred.

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