Filmless in 60 Days: The Impact of Picture Archiving and Communications Systems Within a Large Urban Hospital

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Many large urban hospitals converting to filmless radiography use a phased approach for digital imaging implementation. In fact, this strategy often is recommended by picture archival communication systems (PACS) experts and vendors alike for large, busy hospitals installing PACS in existing physical facilities. The concern is that comprehensive conversion from film-based to digital imaging may be too overwhelming an adjustment in operations for a medical staff to effectively handle without serious disruption of workflow for patient treatment and care. Elmhurst Hospital Center is a 543-bed hospital located in the Borough of Queens in New York City. Owned by the New York City Health and Hospitals Corporation, this municipal teaching hospital provides services to a patient mix that is 38% indigent with no insurance, 50% covered by Medicaid or Medicare, and 12% affiliated with HMOs. Most inpatients are admitted through the emergency department. Forty-five percent of all radiology procedures conducted are for emergency patients. Historically, up to 25% of all diagnostic imaging examinations were never reported formally by radiologists. Report turnaround time for the remaining 75% was unacceptable, with only 3% of all imaging examinations reported within a 12-hour period in 1996. Both situations existed in great part because physicians and residents who felt they needed access to films simply took them. Many were never located or returned days after they were taken. In 1998, Elmhurst Hospital Center replaced its RIS and added voice recognition dictation capabilities in January 1999. A hospitalwide PACS was deployed 10 months later. With the exception of mammography, the hospital converted to filmless radiography within 60 days. The critical objectives to maintain control of films and radically improve the reporting process were achieved immediately. Over 99% of all examinations now are formally reviewed and reported. Only 7% of all reports take 1 or more days to generate. This report describes Elmhurst Hospital's efforts to make improvements in the delivery of radiology services and the reasons attributed to its rapid conversion to becoming a filmless (mammography excluded) medical center. The impact of the PACS on radiology department operations and service is discussed.
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ELMHURST HOSPITAL CENTER is a 543-bed medical center located in the Borough of Queens in New York City. It is 1 of 2 hospitals (the other is Queens Hospital Center) that constitute the Queens Health Network, 1 of 8 networks of hospitals and medical centers owned and operated by the New York City Health and Hospitals Corporation (HHC). Collectively, these hospitals receive approximately 5,000,000 patient visits per year, a number that increases annually.

Of these hospitals, Elmhurst Hospital Center has one of HHCs busiest emergency departments, logging over 125,000 visits in 1999. As a municipal hospital with a designated level 1 trauma center and 911 receiving station serving a culturally diverse, economically challenged, inner city population, weekends in Elmhurst's Emergency Department are especially busy. The hospital operates a large ambulatory care walk-in clinic; 475,000 outpatient visits were recorded in 1999. The same year, there were approximately 26,000 inpatient admissions. The radiology department performed approximately 116,000 procedures, an increase of 4,000 procedures from 1998.

The radiology department is staffed 24 hours a day. There are 14 FTE (full-time equivalent) radiologists, of whom, 5 are specialists in mammography, nuclear medicine, neurology, and pediatrics. Radiologists are employees of Mount Sinai Medical School and members of the Elmhurst Hospital Physicians' Union. (At times, residents from Mt Sinai School of Medicine with which Elmhurst is affiliated, have supplemented this staff.) As union members, each radiologist works an 8-hour shift. Examinations that do not get reviewed at the end of one shift await the next. Overtime is computed by either compensatory time off, or the radiologists are paid on an hourly session basis.

The department facility itself is centralized. The film library is located within the department and did contain 1 year's worth of patient examinations. The remainder are located in the hospital's base-

ment. Because many patients visit Elmhurst Hospital only to be treated for injuries incurred by accidents, and because many do not return for follow-up treatment in spite of scheduled appointments, there is less of a need than other hospitals' radiology departments to have to regularly retrieve prior examinations.

Like many teaching hospitals, the ability to track and manage the location of patient films had been a consistent problem for years. The pace of an urban hospital is a busy one; the film library was understaffed. With 45% of all requests for radiology procedures initiated from the emergency department, the fact that films of emergency patients moved with the patients before radiologists could report them seriously exacerbated the lost film problem. Other films were spirited away by residents and medical faculty before they were read and reported. The result was that up to 25% of all examinations were never reported formally as measured by statistics at the end of each month. In 1997, with approximately 114,300 procedures performed, this equated to approximately 28,575 unread examinations.

File clerks were assigned formally to search for films on a regular basis. Cartloads would be retrieved from throughout the hospital and returned to the radiology department to be read. These would then be duly reported, often a week or more after the date the procedures were taken. In 1996, 97% of all examinations took 12 or more hours to be reported. The combination of lost films and slow reporting stimulated the practice of physicians to routinely reorder examinations for some of their patients if they did not receive a report from radiology in a clinically "reasonable" time period. It was not an uncommon phenomenon for a duplicate examination to be reported before the original one.

Elmhurst Hospital endeavored to get control of its film problems in many different ways. In addition to the film roundup crews, a conference room with a multiviewer was installed in the radiology department. Films taken during the afternoon and night shifts were loaded by night staff for immediate morning viewing and discussion by radiologists and referring physicians alike. However, these physicians were busy and did not want to take the time to come to the radiology department to confer with the radiologists.

An intrahospital image distribution system link-ing the intensive care unit with the radiology department was installed in 1990. Films were digitized in the radiology department and transmitted immediately for viewing in the intensive care unit (ICU) and in the emergency department. Although this mini-PACS was then state-of-the-art, the quality of the images generated by the laser film digitizer combined with the limitations of 1K low luminance monitors did not provide a satisfactory degree of detail for all examinations. In the emergency department, the problem was exacerbated by the fact that bright fluorescent lights shown on the monitor of the viewing station. These 2 factors generated mistrust in image fidelity by the clinical staff regardless of the image displayed. The system was viewed with suspicion and underutilized both in the ICUs and in the emergency department.

QUANTIFYING PERFORMANCE PROBLEMS

During 1997, a hospitalwide performance improvement project was launched. Ancillary test utilization was evaluated to determine specifically why tests were ordered, which tests were duplicated, and reasons for duplication. With respect to radiology, 2 findings were confirmed formally:

1. Physicians ordered some tests based on habit more than clinical rationale. These tests could be identified readily. For example, it was typical for a chest x-ray to be ordered every day for each patient in the ICU. The hospital administration questioned both the need and safety of this procedure for extended stay ICU patients. The radiologists worked with clinicians to establish protocols that made more clinical sense. To some degree, this reduced the number of unnecessary procedures being ordered.
2. If a physician did not receive a test result within a specific amount of time, the test was reordered. The main problem areas were the laboratory and radiology departments. A large number of repeat examinations were being ordered, and the physicians still could not get film or an interpretation rapidly enough. More than a change of protocol was needed to resolve this problem.

A new chairman of the radiology department assessed its radiology services. The investigation undertaken in 1997 statistically verified unacceptable conditions that were obvious to all. During

1996, only 74.7% of all examinations were interpreted by radiologists as measured by end-of-the-month statistics. Over 27,000 examinations, the remaining 25.2%, never were reported as measured by the end of each month. They simply disappeared. Only 3% of all examinations were reported in 12 hours, and only 13.5% were reported within 24 hours, yet, 45% of all examinations generated were for emergency patients who needed diagnostic results rapidly.

PLANNING FOR NEW TECHNOLOGY IMPLEMENTATION

A number of administrative changes were made to improve turnaround time by modifying internal procedures. New methods of sorting films were implemented. The batching of film before reading was eliminated. A radiologist was located closer to the emergency department and computed tomography (CT) areas, and the dictation of reports during ad hoc consultation dramatically improved. In 1998, 33.8% of reports were reported and approved within 24 hours. But this level of improvement was still not an acceptable standard, and film loss had not diminished in spite of these efforts.

During the same time that the radiology department was making workflow and procedural changes, a technology planning team was formed. The existing radiology information system was neither HL-7 or Y2K compliant. It was scheduled to be replaced as part of a hospital information system upgrade in the ambulatory care clinic. The HIS system had a radiology package that would permit order entry and scheduling. The department decided to add voice recognition dictation to obtain immediate turnaround time for dictated reports, eliminating conventional dictation utilizing an off-site transcription pool. The Per Se Ulticare RIS (Atlanta, GA) and Talk Technology, Inc (Bensalem, PA) TalkStation/Radiology (Version 1.8 using IBM Medspeak; Hawthorne, NY) were integrated together and became operational in January 1999.

To eliminate film loss, it was obvious that the radiology department needed a PACS. Studies being published about the use of computed radiography, mini-PACS, and large-scale PACS systems all were verifying that film loss was reduced to less than 2%.[1,2] Elmhurst Hospital was not adverse to PACS technology. In fact, a modality mini-PACS had been purchased in 1995. This system never could be made to work reliably and efficiently, and its vendor failed to make good on its many promises. The experience was bittersweet; the radiologists were exposed to soft-copy reading, and hospital administrative managers saw the potential benefits of filmless radiology. But the investment was wasted. The system never worked properly.

From Elmhurst Hospital's perspective, several lessons were learned from this experience: (1) use a large, well established PACS vendor; (2) make certain that the vendor has service facilities in the area; (3) duplicate all cabling and hardware for reliability; (4) contract for on-site vendor provided service personnel to have primary responsibility for the equipment; (5) choose a turnkey operation, with the vendor being responsible for all interfaces and cabling. By doing this, eliminate any possibility of vendor finger pointing.

The core PACS planning team included the director of radiology, the radiology administrator, the RIS coordinator, and the associate executive director for professional services, our senior management representative. At Elmhurst Hospital, the associate executive director oversees the clinical departments of radiology, pathology, cardiology, and the pharmacy and reports directly to the executive director. All were veterans of failed PACS experiences. Before joining Elmhurst Hospital, the director of radiology worked in a major urban hospital with a less than optimally configured PACS system, and therefore knew firsthand as a radiologist the problems a dysfunctional PACS could cause.

Much has been written in the literature about proper planning for a PACS.[3-8] The planning activities undertaken by Elmhurst's PACS Planning Team were a textbook case of what should be done. From January to November 1997, needs assessments were prepared, workflow was carefully tracked, facilities requirements were assessed, and necessary facilities modifications were planned for or implemented. A variety of informal surveys were conducted with the users of the radiology department's services. The PACS planning team conducted evaluations of vendors' products as it began to assemble RFP requirements. After identifying hospitals with installed PACS that worked, their operations were independently evaluated by our team.

Based on prior experience, Elmhurst's mandate was "buy the solution, not the system." The thor-

ough work of all participants in the PACS planning activities, which included clinicians, information systems specialists, network experts, and facilities engineers and the utilization of a published "RFP Toolkit" resulted in the preparation of 290 performance, generic hardware, generic software, and cabling specifications.[9] Wary of vendors' promises, it was imperative to the PACS planning team that the vendor we selected could show us a hospital using a fully filmless, fully redundant PACS.

The Executive Director of Elmhurst Hospital Center was a very strong advocate of our PACS proposal. His enthusiasm and support was of great benefit. The PACS Planning Team made detailed presentations to the Vice President for Medical and Professional Affairs for the New York City Health and Hospitals Corporation, HHC's Medical and Professional Affairs Committee and ultimately the corporation's General Board of Directors. Capital expenditures of $6,000,000 were approved and released for use in 1999. Elmhurst Hospital Center became the pioneer for the other HHC hospitals whose PACS planning efforts were underway. It was Elmhurst's responsibility to set HHC's standards for the conversion of radiology departments to fully digital imaging.

VENDOR SELECTION

Selection of a vendor who would meet our performance, reliability, installation, training, and service requirements was a key ingredient for our rapid deployment of hospitalwide PACS. From RFP responses, 3 vendors were selected as finalists. Site visits were conducted in July 1998. No one vendor actually met all of our specifications, but we selected the one that had the best proposal score, had proven turnkey experience in PACS implementation, and showed us a PACS that not only worked during the site visit but worked when we returned independently to visit it again. A purchase order was issued in March 1999. A decision was made to postpone installation until the release of a new hardware and software platform by our vendor, which was just a few months away.

MATERIALS AND CONFIGURATION

Conventional x-ray equipment was replaced by computed radiography and digital radiography equipment. Because patients admitted through the emergency department generate 45% of all examinations, one CR reader and related ID and postprocessing terminals (Agfa ADC Compact; Ridgefield

Park, NJ) were placed in the emergency department, one in the operating room, one in the orthopedics department as well as 2 in the radiology department. A single digital radiography chest unit (GE Medical Systems DR Digital Chest; Milwaukee, WI) provides the same throughput as the 2 high-capacity chest rooms it displaced.

Modalities connected include 2 CTs, one magnetic resonance imager (MRI; located at sister Queens Hospital), 1 Digital Angiography unit, 4 Nuclear Medicine units, and 4 ultrasound units. A laser film digitizer (Lumisys Lumiscan Model 75; Sunnyvale, CA) combined with a film digitizer workstation (Agfa IMPAX TS5 Transmit/Preview Station) provided the ability to digitize film of prior examinations for softcopy comparison.

Thirteen diagnostic workstations with 2K monitors were purchased. The radiology department was equipped with 4 4-monitor workstations (Agfa IMPAX DS3000 Diagnostic Display Station) and 3 dual monitor workstations, 1 of which was located in the CT suite. Two diagnostic workstations equipped with 2 1K color monitors were dedicated for nuclear medicine and ultrasound review.

The emergency department also was equipped with a high-resolution single monitor diagnostic workstation as was each surgical intensive care unit (SICU) and respiratory intensive care unit (RICU). The neonatal ICU has a clinical review workstation (Agfa IMPAX DS3000 Clinical Display Station) with dual 1K monitors.

Extensive use of Web client software installed on existing PCs provides PACS access to the remainder of the hospital. Distribution includes the radiology department (1), the emergency department (3), the 2 orthopedic clinics and the orthopedics surgical office, and several other clinics and wards. The web server (Agfa IMPAX Web 1000 Server) has the capacity to support 200 concurrent users, and almost all are connected to HIS terminals.

The system has on-line RAID storage capacity to hold the equivalent of 40 days of examinations. Images are archived on 2 500-platter magnetic optical disc (MOD) jukeboxes. A backup digital linear tape (DLT) archive is located off site to provide disaster data recovery. A PACS interface engine (Agfa IMPAX RIS Broker) connects the RIS (Per Se HDS) and the voice recognition dictation system (Talk Technology) with the PACS (Agfa IMPAX Software Version R4).

INSTALLATION AND LAUNCH

Modifications to facilities began in the spring. The project implementation schedule was as rapid and condensed as we had specified. Events happened as scheduled. Elmhurst Hospital effectively converted to filmless radiology services within 60 days (Table 1).

CRITERIA FOR A RAPID CONVERSION

Subsequent to our PACS implementation, it became apparent that the ability to convert rapidly to filmless radiology is not considered to be the norm by most hospitals. Elmhurst Hospital Center's success is attributed to many factors, the first being the

Table 1. Conversion Timeline

Date	Action
1999	
July-September	Network installation.
September	Computed radiography equipment delivered and installed.
October 1	Training of technical staff on the use of CR. Interface of CR equipment with PACS digital archive. Clinical use commences, with examinations both archived and printed to film.
October 15-30	Remainder of PACS equipment delivered. System installation. Integration with RIS. Acceptance testing. PACS Administrator and technical support staff trained.
November 1-14	Training of radiologists, clinicians, nurses and clerical staff throughout hospital.
November 15	THE LAUNCH! Softcopy interpretation began in most areas.
December 1	Printing of CR generated images is terminated.
2000	
January 1	Printing of film (except for mammography) is terminated.
February 1	Retrieval of all film folders for conferences is discontinued. Lightboxes are removed from conference rooms. Examinations are now presented on high quality video projectors in conference rooms connected to the PACS Web Server.
March 1	Retrieval of film folders for clinic visits is discontinued. Clinicians view examinations on HIS terminals connected to the PACS Web Server.

desire and necessity to succeed. Others include the following:

The months of careful planning and preparation by the core group and extended PACS planning team should be equated to being the backbone of this project. The more thorough the preparation and planning, the better potential for success.

The PACS planning team was experienced with use of the technology. This team knew from first-hand experience many of the problems and pitfalls to avoid. A professional consultant can provide this expertise if it does not exist among hospital staff.

The PACS planning team believed in its work and were strong vocal advocates for the program.

The PACS planning team benefited from the enthusiastic support of Elmhurst's Executive Director and technology-oriented members of the HHC. For a city government agency to approve a $6 million investment in an early adopter-stage technology, the leadership included strong advocates for change and the use of technology that can improve hospital operations and consolidate scarce clinical talent. The HHC did not create unnecessary roadblocks. The project was approved by this bureaucracy with efficiency.

A comprehensive digital solution was needed to resolve the lost film problem. Phased implementation of a PACS would not have brought the results we required to achieve the projected return on investment.

As a unionized hospital with a salaried staff of radiologists, the PACS planning team did not get undermined by powerful, risk-adverse radiologists with individual political/professional agendas. A similar scenario is attributed to the success of the first United States military hospital PACS installations.

On the whole, the problem of lost films had such a pervasive impact throughout hospital operations that the liberation provided by a PACS to have immediate access to any examination needed generated a positive attitude of support and determination to work with the system by all of the staff. Problems that individual clinicians had with the workstations were resolved rapidly. The clinicians who were anxious to benefit from PACS technology were very supportive.

Incorporated in the purchase price of the PACS was a substantial training package. A larger number of trainers supported Elmhurst Hospital than is normally sold by a vendor or purchased by a customer. On-the-spot training and coaching by applications specialists during the initial weeks of the launch created a comfort level that would not have been achieved so rapidly. Their work was supplemented by the radiology administrative staff working on their own time during second and third shifts to train users. The impact on the level of training and the correlation with successful implementation of a PACS has been discussed at length in published literature.[10,11]

A staff of 5, one of whom is a vendor-contracted, full-time service engineer, keep the PACS running smoothly around the clock. These individ-

uals provide much needed user support as well. For some users, it is easy to panic over simple things, such as seeing an image upside down. The PACS technical staff provides immediate assistance, creating an environment in which it is safe to learn because answers are within a telephone call away if a user gets stuck. Having an adequate support staff for all 3 shifts 7 days a week is a critically important factor for success.

The radiology reading area was designed specifically for workstation use. The hospital architect worked with our director of radiology to design a facility that had adequate air conditioning and room circulation as well as sound insulation. Sound deadening booths were designed to further reduce workstation noise. Very low-level dimmable indirect lighting was installed. This prevents illumination from shining directly on a monitor's surface and prevents reflections from one monitor to shine on another. Glare factor was also taken into account when positioning and partitioning workstations and when selecting fabrics for carpets and wall coverings. X-ray viewboxes were located in the vicinity of the PACS reading areas but not directly in the same location as the monitors. (After 6 months of operation, these were used less than once a week.) An ergonomic design conducive to softcopy reading has contributed to its acceptance.

The number of diagnostic workstations in the department of radiology was determined by dividing the weekday dictations into 15-minute intervals from 8:00 AM to 6:00 PM and, by utilizing the radiology information system, determining how many radiologists were dictating during any single 15-minute period. The maximum was 7. The number of diagnostic radiologists' workstations chosen was 9.

The number of diagnostic workstations was not limited to the radiology department. High-resolution (2K × 2.5K), single-monitor workstations were installed in the emergency department and the 4 ICUs so that they would not be at a disadvantage in interpreting studies in comparison with the radiologists. Each of the 8 operating rooms had a single monitor 1.5K workstation as well as in the clinicians' viewing areas in the radiology department.

A PACS Web server enables authorized users throughout the hospital as much access as they need to patient examinations. The display resolution of images meets the requirements of most viewers. Four classrooms were equipped with high-resolution (XGA, 1900 lumen) fixed video projectors to display Web images. Also, each department has been equipped with a CD ROM Writer for extra-institutional conferences.

Having a radiology administrator who wanted to implement new technology to improve department operations, who conveyed his enthusiasm to the staff, and who was able to resolve problems rapidly was of immeasurable value. In addition, the clerical staff of the film library was reassured that no one would lose a job. Most have transitioned into clerical PACS support functions. Others have transferred to different areas of the hospital. The decision to reduce staffing through attrition minimized concerns and generated union buy-in.

IMPACT ON RADIOLOGY SERVICES PERFORMANCE

The rapid hospitalwide implementation of conversion to filmless imaging has affected every department and clinician in the hospital who has a need to either read radiology reports or view patient images. Quantitative analysis of unread films primarily because of film loss and report turnaround time shows the impact of the PACS.

Reduction of Unread Films

In 1997, between 21% and 28% of all procedures conducted were not reported by the end of each month. By implementing a variety of operational changes within the radiology department, this dropped to a range of 14% to 15% in 1998. Although this was a great improvement, approximately 17,500 examinations went unreported and unbilled with respect to professional fees at the end of each month. All of the physicians at Elmhurst Hospital Center are members of the Mount Sinai Medical School Affiliation staff and all share equally in collected faculty practice fees. The loss of revenue because of unreported examinations represents a loss in income for every member of the medical staff. Because of the high percentage of indigent patients and Medicaid patients, the physicians primarily are salaried but derive a minor additional portion of their income from professional collections. Using a composite average of $17 per examination, this represented an unnecessary loss of about $300,000 in unrecoupable revenue for professional services in a 2-year period.

Figures 1 and 2 show the number of total pro-
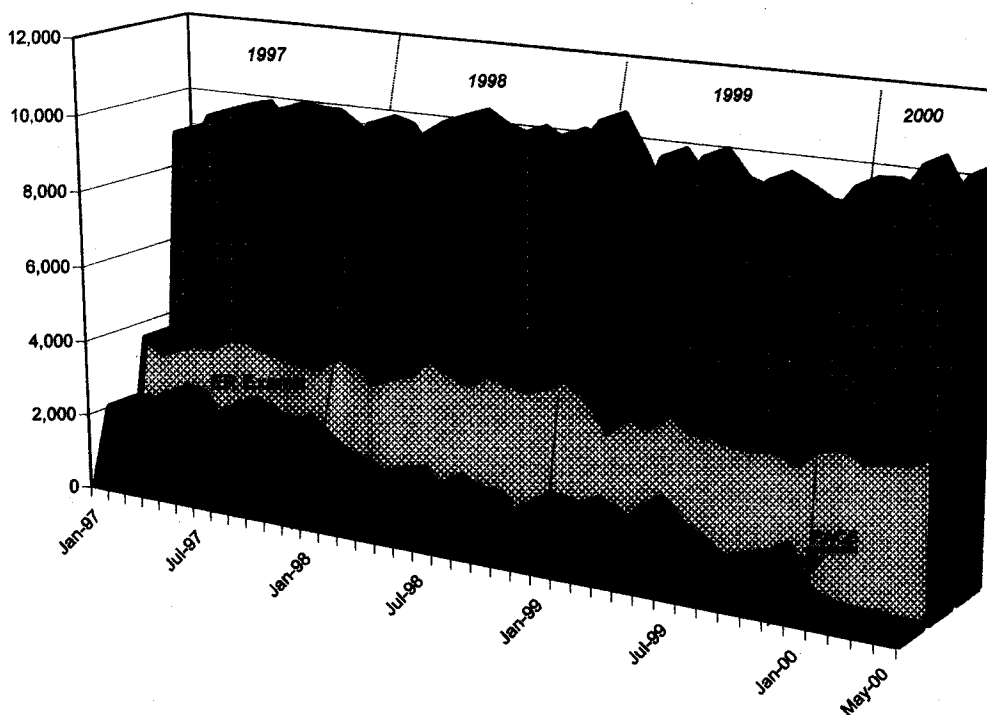
Examination Volume at Elmhurst Hospital Center

Fig 1. Examination volume over a 4-year period for the total number of procedures performed and the percentage of examinations ordered for emergency patients is consistent.

cedures performed, the number of procedures performed for patients admitted through the emergency department, and the number of unreported examinations for calendar years 1997, 1998, and 1999 through May 2000.

The voice recognition digital dictation system was activated mid January 1999. The PACS was fully operational by December 1999. The number of unreported procedures plunged from 1,452 to 397, an improvement of over 400%. As the staff became proficient at correcting demographic errors and inconsistencies that can create problems identifying patients with examinations in the PACS database, the percentage of unread images has declined steadily. As of May 2000, only one half of 1% were unread, a total of 56 unread examinations as compared with 2,059 unread examinations in May 1999.

What this 0.55% loss rate represents in recaptured revenues is substantial. In comparison with statistical monthly average in 1998 of 15.28% and a 1999 average of 13.55% (representing 11 months

of the year before PACS was operational), bringing the loss rate down to 0.55% means that the department will generate an additional $356,881 in professional fee revenue during the first year after PACS implementation.

Improvement in Report Turnaround Times

The introduction of a digital voice recognition system dramatically improved report turnaround time for the percentage of examinations reported within 12 hours of being performed. From April 1998 through mid January 1999, a consistent 7.4% to 9.6% of examinations were reported within 12 hours. (Fig 3.) Within the first 2 weeks of implementation, 40% of examinations were reported in this time frame, the number of examinations reported within a 24- to 48-hour period dropped from 25% to 11% and those reported more than 48 hours after the procedure dropped from 47% to 27%. As radiologists became more proficient using the system, these statistics rose to 65%-66% for report turnaround within 12 hours, 11%-15% in the 12- to

Percentage of Examinations Lost and Not Formally Reported

A = Voice Recognition System Activated
B = 24x7 Radiologist Services Provided
C = PACS Activated
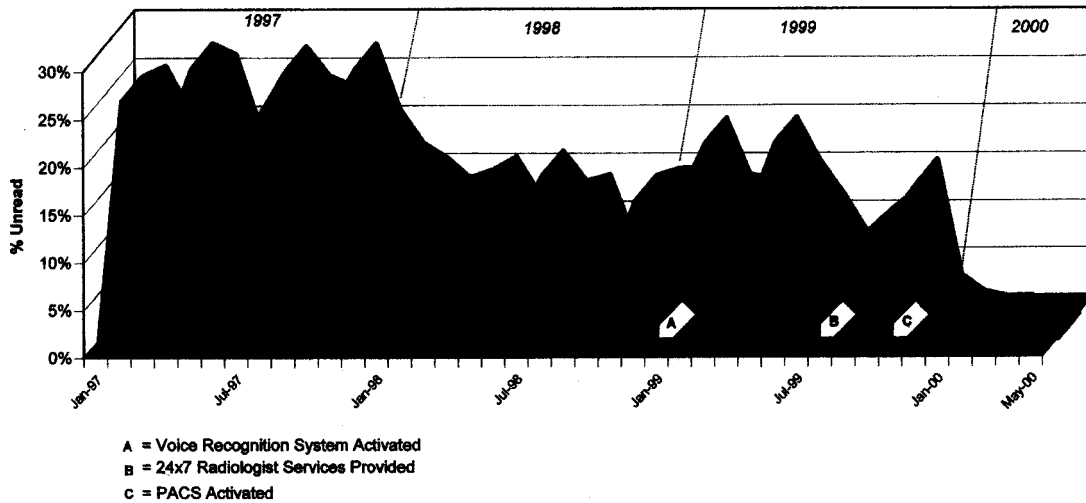
Fig 2. With the installation of a PACS, the percentage of unreported examinations drops dramatically and levels out at less than 1%.

24-hour period, 8%-9% in the 24- to 48-hour period, and 10%-14% over 48 hours.

Commencing in August 1999, a 24-hour-a-day, 7-days-a-week staff of radiologists proficient in all aspects of CT interpretation as well as plain film interpretation was recruited for around-the-clock coverage. This level of coverage significantly helped improve turnaround time.

During November, as radiologists were learning to use the PACS and become proficient in softcopy reading, productivity dropped. However, by December, the impact of PACS being used in conjunction with voice recognition was very noticeable. Reporting times in 3 of the 4 categories had improved above the records set in October 1999. Statistics gathered for the most recent 90-day period of use are impressive. Eighty-four percent of all examinations are reported in the first 12 hours, whereas only 7% exceed a 24-hour reporting time. Additional gains are expected when a new, more efficient generation of voice recognition software upgrades our system.

Elmhurst Hospital Center has only begun to quantify the impact that reports delivered in a timely manner to the clinicians who need them and hospitalwide access to films has made to patient treatment and care. It is expected that requests for repeat studies will be almost completely eliminated, that stays by critically ill in the ICU may be reduced by some percentage, and that the timeliness of appropriate patient treatment also may have a domino effect, both on the quality of patient care and on the hospital's bottom line.

There have been other nonquantified improvements that can be attributed to our hospital-wide PACS implementation:

The Radiology Department has experienced a marked reduction of information-type consultations with radiologists. This has reduced the number of interruptions to our radiology staff. Problem consultations now are the primary reason for consulting a radiologist. This same drop in clinician-radiologist communication has been reported by the Baltimore Veterans Affairs Medical Center.[12]
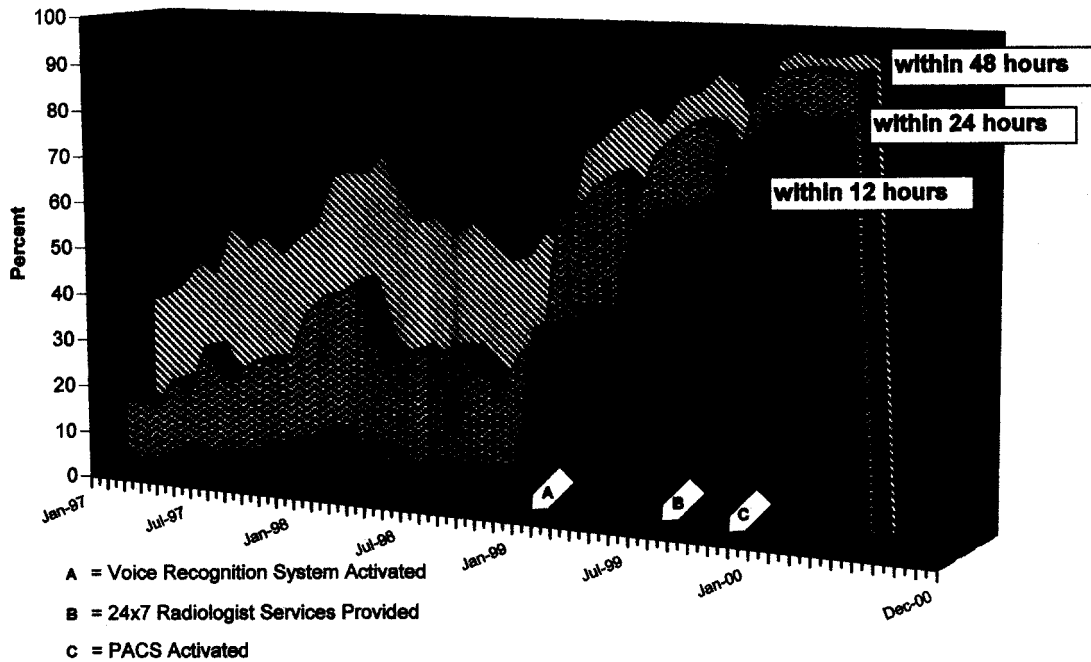
There has been marked acceptance by the clinical staff of the availability of images in the operating rooms, in the orthopedics department, in the pulmonary medicine department, and in general in teaching conferences and rounds. Now that images are accessible, previous competition for and sequestering of image studies (priors) has disappeared.

The orthopedic clinic has become more efficient. This clinic commenced at 1:00 PM. Before PACS installation, it would not end until 6:00 or 7:00 PM.

Report Turnaround Times - 1997 through May 2000

% of Examinations Formally Reported

A = Voice Recognition System Activated

B = 24x7 Radiologist Services Provided

C = PACS Activated

Fig 3. This chart illustrates that report turnaround times of reported examinations show minimal improvement over a 24-month period in spite of efforts undertaken within the radiology department to improve them. With the introduction of a voice recognition dictation system, on-site radiologist coverage on a 24-hour basis, and PACS, Elmhurst Hospital Center now consistently provides 84% to 85% of all reports within 12 hours. Only 7% of examinations have a report turnaround time exceeding 24 hours, even though up to 20% more examinations are being read and reported than in 1999.

With the availability of the previous imaging studies and new imaging studies obtained at the same time as the clinic is in progress, the clinic now finishes by 5:00 PM.

Stress has been reduced significantly. There is no need to search frantically for films anymore. All staff can focus more on their jobs and perform their jobs more efficiently knowing that films and digital images can be found.

There is improved comparison with previous studies. Because of the chaotic availability of previous examinations, comparison rarely was possible. Comparisons are becoming standard now, because an increasingly greater number of previous studies are found in the digital archive.

Clinicians have become used to reading radiology reports. Clinicians in the emergency department now access images immediately and the reports shortly

thereafter. Clinic visits, representing the second highest source of imaging requests, became served with officially reported examinations.

On the inpatient side, there has been a reduction in length of stay so far in the year 2000. However, it cannot be stated with any certainty that this is attributable to PACS.

The purchase of a digital radiography chest unit has increased workflow of chest examinations by 200%. One unit is now doing the work of 2 chest rooms. The unutilized chest room has been converted to a much needed mammography stereotactic biopsy room.

THE NEGATIVES

The process of reading an examination using soft copy display is taking radiologists longer than using film. The voice recognition system has not

been easy to use. Approximately 50% of the time spent in the dictation of an examination is spent making corrections. This means that it takes the radiologists approximately double the amount of time to interpret examinations with voice recognition versus traditional dictation. A new version of voice recognition has been introduced recently (Talk Technology Version 2.0; Bensalem, PA). Use of this new improved software now closely approximates the time taken to dictate and correct transcribed reports. Statistics are being collected so that comparisons of productivity using improved software can be obtained. Continued improvements in report turnaround time is expected.

Also, the PACS system itself appears to be slightly faster to use than the hand hanging of films, but not as fast as a preloaded automatic viewbox.

The lack of clinical to radiologist consultations in some cases reduces the accuracy of diagnoses because the supplied clinical information on computer-generated requisitions is minimal and on handwritten requisitions often is illegible.

CONCLUSIONS

Implementation of a hospitalwide PACS has achieved an improvement in radiology services that were unachievable by other means. With the aid of a PACS, Elmhurst Hospital Center gained complete control of a runaway film problem, reducing lost films to 0.01% and unreported films to less than 1% in a matter of 5 months. With the combination of voice recognition and PACS, report turnaround time changed from being completely unacceptable to reaching acceptable turnaround rates. The benefits resulting from these 2 factors alone are undocumented but have been substantial for both physicians and their patients.

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