

# The Pros and Cons of Implementing PACS and Speech Recognition Systems

David B. Hayt and Steven Alexander

The installation and implementation of a hospitalwide image management system and a speech recognition dictation system has had a dramatic and positive impact on radiology report turnaround times at Elmhurst Hospital Center, a 543-bed municipal teaching hospital located in New York City's Borough of Queens. The "lost film" problem has been eliminated. As a result, the percentage of unreported examinations has dropped from 25% to less than 1%. These performance improvements have significantly benefited the entire medical staff. With the successful implementation of a HL-7 standards-based radiology information system (RIS), a speech recognition dictation system, around-the-clock staffing of Board Certified radiologists, and a picture archiving and communication system (PACS), report turnaround time improved dramatically. Eighty-six percent of all examinations now are reported formally within a 12-hour period compared with a 3% average before implementation of the changes. However, with the use of the PACS and speech recognition technologies, new problems have arisen within the radiology department. These technologies, designed to enhance communications capabilities, also have significantly reduced the amount of clinician/radiologist dialogue. Easy and rapid access to patient images and reports has had a detrimental effect on that face-to-face consultations with clinicians, which were commonplace before PACS, and now have almost completely disappeared. The radiologist/clinician interchanges, which occurred frequently before a final report was dictated, often resulted in better understanding of the clinical problem and, hence, a more meaningful final report. Although a conferencing feature to facilitate communication exists within the PACS, it is not utilized by the clinicians. The dilemma is that as information about patients is made more available to the hospital staff, less information is provided about patients to the radiologists. Although the speech recognition system benefits the hospital, its staff, and the patients served by reducing clinician time awaiting a diagnostic report and reducing clinic and emergency room waiting time by the patients themselves, it does not necessarily benefit the radiologists who use it. Speech recognition dictation systems slow down the individual productivity of the radiologists' dictation process by at least 25%. Radiologists are assuming the role of transcriptionists as well as diagnosticians. Mistakes occur that would not with the use of a traditional dictation system and professional transcriptionists.

Copyright © 2001 by W.B. Saunders Company

**KEY WORDS:** picture archiving and communication systems, continuous speech recognition systems, Radiology report turnaround time, radiology workflow, radiologist consultation, filmless radiology.

**E**MHURST HOSPITAL CENTER, a 543-bed municipal teaching hospital located in the Borough of Queens in New York, a level 1 trauma center and 911 receiving station, installed its hospital-wide picture archiving and communication system PACS; IMPAX R4; Agfa Corporation, Ridgefield Park, NJ) over a 2-month period at the end of 1999, after first converting to a HL-7-compliant RIS (Per-Se Ulticare; Per-Se Technologies, Atlanta, GA), a speech recognition system (TalkStation Radiology; Talk Technology Inc, Bensalem, PA), and expanding around-the-clock, on-site radiologist coverage. The details about this installation have been reported previously.<sup>1</sup>

After the installation of a speech recognition dictation system, the percentage of reports present in the hospital information system within 12 hours after dictation increased from 3% to 42%. After around-the-clock, full-time radiologist coverage for definitive reporting of plain films and computed tomography (CT) scans was instituted, this percentage increased to 66%. With the addition of PACS, 50% of all examinations had reports available within the hospital information system within 60 minutes. Eighty-six percent became available within 12 hours, and 96% of all examination reports were available within 24 hours. The average report turnaround time was 4 hours, 19 minutes. The average actual turnaround time may be slightly lower than this number, however, because certain radiologists read cases (utilizing the clinical information present on the PACS monitor) before the technologist actually signed off on the case. For this reason, other measures of turnaround time such as mean, median or determining the standard deviation also would be slightly inaccurate. The quantitative information described above was obtained from the management reporting module of the radiology information system.

---

*From Elmhurst Hospital Center, Elmhurst, NY.*

*Address reprint requests to David B. Hayt, MD, Radiology Department (E1-18), Elmhurst Hospital Center, 79-01 Broadway, Elmhurst, NY 11373.*

*Copyright © 2001 by W.B. Saunders Company*

*0897-1889/01/1403-0006\$35.00/0*

*doi:10.1053/jdim.2001.28994*

By May 2000, with the use of a PACS, the percentage of unreported cases at the end of each month had dropped from approximately 25% in 1997 to 0.3%, as derived from the RIS management data. This small percentage of unread cases was caused by the misplacement of x-ray requisitions and is similar to the unread case statistics of other medical institutions with hospitalwide PACS installation.<sup>2</sup> This analysis contains both anecdotal and quantitative information.

#### REACTION BY CLINICIANS

The response to a physician satisfaction questionnaire indicated that the clinicians generally were pleased with the accessibility of images and reports in a very timely manner. The clinicians who responded (21%) estimated that each saved 30 minutes a day on average as a result of the PACS. The orthopedic clinic, for instance, now ends at 5:00 PM instead of 7:00 PM because of the rapid turnaround of images because of PACS.

Because report turnaround time has diminished steadily, the expectations by the clinicians for immediate access to these reports has escalated. This is true especially with respect to the emergency room clinical staff. Examinations for emergency patients receive STAT priority and are dictated immediately, with a 1-minute time interval to transfer the report via the radiology information system to the hospital information system and then be populated into PACS. Whereas previously, emergency room clinicians would wait hours for reports, they now expect instantaneous reports. As a result, some of the physicians with really emergent cases who do not see a report associated with images displayed on the ER PACS workstation immediately walk over to the radiology department next door and seek out the radiologist reporting STAT emergency images. During that 1- to 2-minute walk, the dictated report has often entered the PACS system and is available to the emergency room physician to read, much to his or her surprise. However, the radiologists welcome these impromptu visits because it provides the opportunity for more clinical input and dialogue about the patient.

Occasionally, the radiology department receives irate calls from the emergency room staff that not all of the images on a particular examination are available for review. The usual cause of this is that the patient still is on the table being radiographed.

The PACS and speech recognition systems have created a new set of expectations throughout the hospital about the deliverables expected from the radiology department.

#### REACTION BY RADIOLOGISTS

Although the emergency room clinicians and others are pleased with the addition of PACS, the reaction by radiologists has been much more mixed. The radiologists like the ability to retrieve previous studies promptly, to magnify and window/level computed radiography and digital radiography images, and equalize the appearance of portable images from day to day. Soft tissue findings on computed radiography, such as varicose veins, can now be identified. Through the combined use of magnification and window/leveling tools, pneumothoracies are evaluated more easily, and questionable fractures can be confirmed. These were the most frequent compliments by the radiologists. All of these capabilities facilitate the diagnostic process.

However, the speech recognition dictation system in particular, and to a lesser degree, its lack of integration with the PACS, has reduced perceived individual radiologist productivity.

In June 2000, approximately 6 months after the introduction of PACS and 17 months after the introduction of speech recognition dictation, a formal survey of our 10 regular staff radiologists was conducted. (At that time, we were using Talk Technology's TalkStation Radiology Version 1.2 and Agfa IMPAX Version R4.0) The radiologists were asked: "Does the combination of PACS and voice recognition take more or less time than manual hanging of films on a view box and the use of ordinary dictation equipment?" Given the choice of categories of less time, the same amount of time, or more time spent in increments of 25%, 50%, 100%, or 200%, 2 radiologists reported an increase of 25%, and the remainder reported an increase of more than 100%. (This survey did not factor in the amount of time that a radiologist used to spend proofreading a traditionally transcribed report, which would reduce the overall percentage of time perceived being spent in the speech recognition reporting process. These data had never been measured previously within our department.)

A portion of the slowdown could be attributed to the number of mistakes made when the speech recognition dictation system was utilized. All of

the radiologists who work during the day shift were tested for accuracy of reporting in April 2001. (At this time, we were using TalkStation Radiology Version 2.1 and IMPAX Version R4.5.) This group included one radiologist with a heavy non-native English-language accent. The error rate was 1.8% to 2.75% per 100 words, which is within the range reported by other users.<sup>5-7</sup>

One of our radiologists who does not have a good command of the spoken English language has a much higher error rate than the norm. Recognizing the technologic limitations of the system, this radiologist utilizes macros and modifies them with manual transcription on his own. He has learned to type at 60 words per minute. In effect, the burden of accurate transcription for this radiologist's reports has shifted from a transcriptionist to the radiologist himself.

Because the speech recognition dictation system is not linked directly to the PACS, but rather through the RIS to the HIS and then to PACS, the process of using the 2 systems simultaneously is not as efficient as it should be. It is necessary to barcode the paper requisition for the case into the speech recognition system and then manually select the same case from the PACS worklist displayed on the workstation monitor. This adds 20 seconds per case for each of the approximately 385 examinations read daily. In addition, even more time is spent—another 19 seconds—because the radiologist must return to the main menu displayed on the PACS workstation after completing dictation to be able to select a new case from the workstation. Integration of the 2 systems should reduce some of the wasted radiologists' time maneuvering between the 2 systems.

A more time-consuming problem for all radiologists has been the need to self-correct reports. Because the speech recognition system, unlike a transcriptionist, substitutes incorrect but properly spelled words in a report, it is somewhat more difficult to identify errors. Therefore, the printed report requires careful and thorough scrutiny, and this takes more time than reviewing a transcribed and proofread report. This clearly is a situation in which the radiologists are performing the function of transcriptionists. Although some users of speech recognition systems employ a quality control transcriptionist to review reports in "real time," Elmhurst Hospital Center does not have this financial luxury.

Individual radiologist's productivity also is affected by lack of total automation within the emergency room. Because requisitions for diagnostic imaging examinations for emergency room patients and hospital inpatients are still handwritten, this information is transcribed by the radiology department receptionists into the RIS when entering the patient case. The histories of patients often are transcribed incorrectly because they are illegible, a problem exacerbated by the fact that the radiology department receives a carbon copy of the requisition, not the original. Because there is less face-to-face, clinician-radiologist direct interaction, the clinical information deficiencies resulted in the need for the radiologists to telephone the clinician generating the requisition to obtain the relevant clinical information that he or she considers necessary for proper interpretation.

#### ERRORS AFFECTING PRODUCTIVITY

A survey of errors that occurred with the use of these technology systems was conducted by the department's RIS/PACS personnel between February 20 and March 16, 2001. These were errors reported to the RIS/PACS technical support staff primarily by the radiologists. During this time, 17 radiologist errors, 18 technologist errors, 8 PACS errors, 13 speech recognition dictation system errors, and 0 hospital network failures were reported. These errors reduce overall productivity.

Technologist errors included forgetting to send one or more images generated by the CT or digital radiography images into the PACS system. More frequently, forgetting to take the step to check images generated from the portable image intensifiers used in the operating room for proper orientation caused images to be improperly displayed in inverted, reversed, and sideways format. (Image intensifiers used in the operating rooms often have to be positioned differently for different operations, with the result being that image orientation changes.) Supplemental training for the technologists as well as increasing familiarity with the use of the system helps to reduce these annoying and time-consuming problems.

The second largest group of errors was made by radiologists. The most frequent error was dictating a report assigned to the wrong patient. This problem occurred as a result of the necessity of dual entry of data (bar code swiping the requisition into the speech recognition system and selecting a pa-

tient manually from the PACS). If a technologist failed to send a case into the PACS, the radiologist would move from the patient with the empty electronic jacket to the next patient, but forget to change the order in the speech recognition system to reflect the new case. This problem also occurred when a radiologist was interrupted during reading. If this type of mistake was discovered immediately, a call to the RIS staff would correct the problem. But if there was a delay in discovery, it was necessary to recall the report, and an addendum would be dictated.

Errors with the speech dictation system that were related to the manner of radiologists' dictation were of 2 types. Simple 1-syllable words such as "an" or "of" were most frequently erroneously transcribed or omitted. The second most common error was the addition of unrelated extraneous words owing to pauses during dictation when the radiologist failed to place the microphone on pause, or owing to unusual ambient noise. Because our reading area was designed with sound-absorbing materials, and because each workstation had its own booth, this latter problem occurred quite infrequently.

Elmhurst Hospital Center has experienced using several software versions of the speech recognition system. The first version (TalkStation Radiology Version 1.2) still had some "bugs". These included a definite "unlearning" factor. After the system was trained to recognize certain words, it would unlearn them after a period of time. This required user retraining on the workstation. Crashes during the system's early days would necessitate re-enrollment by the radiologists. Our RIS staff made a CD ROM of each radiologist's voice profile so that it subsequently became unnecessary to re-enroll in person.

An infrequent problem was the loss of stored macros for a particular radiologist. It took time to create the macros, and so the loss of this file was particularly discouraging. By having a regularly updated backup file, this problem was eliminated.

Errors caused by clinicians and the medical staff were surprisingly few. The Web-based system used in most of the hospital is easy to use and allows for access to images combined with reports. Additionally, most of the clinicians actually bringing up patient images and reports on the system are young house staff officers who are highly computer literate. However, although not technically

an error but still a problem, displayed images varied with the quality of computer monitor being used and the amount of ambient light present in the viewing location. The clinical staff needed to be educated about the reasons for the disparities, and, at some locations, changes were made. The hospital information system staff has attacked the problem of image display quality on a case-by-case basis.

Electronic and mechanical errors have been relatively few. Most of these were related to the speech recognition dictation system. Because of the redundancy of design of the PACS, there was only one disruption that occurred 1 month after the initial installation—of course, after midnight on a Sunday night. Once the appropriate personnel were contacted, the problem was solved in 15 minutes. Subsequently, the system was reconfigured with load balancing, placing half of the acquisition devices and workstations on one circuit, and the other half on the other circuit. This design change would enable to PACS to always be in operation even if there was a temporary interruption. Since the correction of this problem, there have been only minor errors in the PACS, and these are relatively infrequent.

Some errors attributed to the PACS system and also the speech recognition dictation system during the survey period actually were caused by individuals who were not familiar with using computers. Errors of this type were relegated mostly to radiologists reconfiguring the position of components of the PACS workstation and the speech recognition equipment. Problems occurred when radiologists accidentally unplugged the microphone, mouse, or keyboard of a workstation when repositioning this equipment. If a radiologist clicked the computer mouse many times in succession as an image was "loading" onto the display screen of a diagnostic workstation, the workstation could get "confused" and fail to perform. (This situation is not unique to our hospital.)<sup>8</sup> One radiologist frequently and persistently hit a main computer switch that would initiate a "hot shutdown" of the workstation.

During the time of the survey, there were no problems with the Hospital Information System (HIS). However, the HIS is not free of problems. Usually, when a failure occurs, it is systemwide and affects the ordering of radiographs, as well as the viewing of reports and images on the Web.

## OPERATIONAL IMPACT ON THE CURRENT RADIOLOGY PRACTICE: THE EFFECT OF INCREASED ACCESS TO INFORMATION

### PACS

The radical improvement in rapid delivery of reports by the radiology department to the clinical departments it serves has put the radiology report in the forefront of medical management within Elmhurst Hospital Center. When the PACS was initiated, the emergency room and intensive care unit staff did not read the radiology report, but rather preferred to view images. This behavior was a conditioning factor. Before the implementation of the new technology, reports were rarely available for use in a timely manner, and the clinicians were accustomed to interpreting radiology films themselves. Today, if the report is not instantly available, physicians do not come to the radiology department with films in hand to discuss the case in a direct clinician-radiologist interaction. Instead they call the reading room with requests for the results.

For clinicians who wish to view images, these are readily available at any computer in the hospital by accessing the Web server or by using a clinical review workstation in the emergency room. The need to pull hundreds of film jackets per day to be sent to the clinics has ended.

The benefit of having immediate report and image access to the clinicians has had an unexpected, detrimental impact on the radiologists. With the exception of neuroradiology, pediatric radiology, and the occasional impatient emergency room clinician, most face-to-face consultations between radiologists and clinicians have ceased. On comparatively rare occasions, there are dialogues between radiologists and clinicians in which each is looking at the same image in different parts of a hospital. This is a moderately frequent occurrence in neuroradiology, but that is the only specialty that has retained a semblance of the former clinician-radiologist interchange. Elimination of impromptu dialogue actually has reduced the amount of information made available to the radiologist to assist in diagnosis.

Although most of the clinician-radiologist consultations were for information purposes, ie, the "what does the imaging study show?" variety, there was considerable physician-to-physician interchange of additional clinical information that

contributed to the direct diagnosis. Today, the radiologists must rely on nearly illegible handwritten requisitions or single word clinical information computer-generated requisitions (such as "pain"), which provide very little guidance.

Furthermore, our radiologists are challenged by dealing with a patient population who do not have common diseases. Elmhurst Hospital Center has the second busiest emergency room in New York City and is the origin of 45% of our imaging requisitions. The hospital provides care to the most ethnically diverse population in New York City, many of whom do not speak English or a language understood by any member of our department. (Although our radiology department staff collectively has the ability to speak 16 different languages, this is vastly insufficient for the population we serve.) In addition to the frequent language barriers that prevent our staff from asking questions directly of the patients, the population also brings with it disease that are indigenous to other parts of the world, such as cysticercosis, histoplasmosis, malaria, and a high incidence of tuberculosis. Therefore, for the most part, the radiologist is now on the front line, without much help from his colleagues or the patients themselves. With the deployment of the new, highly efficient communications technology, the radiologist is rendering an almost instantaneous, final, completed transcribed report in the hospital information system with little knowledge as to the patient's symptoms or differential diagnosis. Translators are available within the hospital to translate virtually all of the more than 100 languages spoken by the patients. However, much of the history is derived after the imaging requisition has been made out. This additional information normally would be conveyed to the radiologist by a face-to-face consultation with the emergency room physician bringing the film with him to show to the radiologist.

Because the report is rendered up front, the window of time to obtain helpful clinical information is diminished. We have come to realize that it is imperative that definitive clinical information be provided at the same time as the request for an examination.

What frustrates the staff radiologists is that the clinicians have been trained extensively in the use of the Web-based dialogue mode in which interactive annotations and arrows can be placed on the image during a live telephone or e-mail discus-

sion.<sup>9</sup> However, they show no inclination to use this tool in spite of the radiologists' requests.

Because there is less direct clinician feedback to the radiologist, an important aspect of any hospital's performance improvement system should include feedback of missed or questionable cases to the radiology department through its Performance Improvement Committee. Performance improvement committees in the radiology departments of some hospitals evaluate perceived radiologist errors and determine whether the standard of care has been met. This is true at Elmhurst Hospital Center. A 2-way dialogue among performance improvement committees to allow the radiologists to be informed of perceived radiologic errors from the clinical committees is more of a necessity in a PACS-equipped hospital, which is rendering reports in a timely manner without much clinician/radiologist interchange. The Radiology Performance Improvement Committee at Elmhurst Hospital Center continually emphasizes the need for this bidirectional dialogue.

### *Speech Recognition*

The capabilities of the speech recognition system have both beneficial and detrimental aspects. It puts the radiology report in the hands of the clinician where it is read and helps in patient management in a real-time manner. It also may reduce radiology errors by enabling the radiologist to correct the report in real time while observing the image, such as to avoid mix-ups like "right" for "left". However, it substitutes highly paid radiologist time for significantly less well paid transcriptionist time, reducing radiologist productivity.

If a radiology department is fully staffed with radiologists to a degree sufficient to manage the speech recognition process, it is certainly the appropriate way to deliver a report in real time. If, however, the radiology department becomes understaffed, the system exacerbates the problem by decreasing the productivity of the already overtaxed radiologists. Since 1995, the number of radiologists entering and leaving this specialty has remained relatively constant, whereas the number of imaging studies has increased.<sup>10-12</sup> There also has been a corresponding increase in the income of radiologists, so that the recruitment of radiologists for a municipal hospital (which is relatively low paying) becomes increasingly difficult. A radiology department considering the addition of a

speech recognition system should determine if it is staffed sufficiently enough with radiologists to manage the increased workload.

Lack of integration of the speech recognition system and the PACS represents a further impediment to rapid workflow for the radiologist who is using both systems. To take full advantage of an integrated system, it also would be necessary to transition to complete electronic ordering with elimination of paper requisitions. This has not yet happened at Elmhurst Hospital Center.

### EFFORTS FOR IMPROVEMENT

The Radiology Department is in the process of deploying a linked system between the PACS and the speech recognition system, which appears to be very promising. With the linked system, a series of cases may be brought up in the PACS display screen with a single mouse click. As each case is brought up, the corresponding order is opened in the speech recognition system. After dictation of the case, it is signed off in the speech recognition system, and then the next case is brought up in the PACS without the need to revert to the main menu.

The linkage has helped increase productivity for users. For each examination, approximately 39 seconds is saved by not having to make 2 worklist selections. The principal author of this paper has tested his own reading speed with plain film examinations using linked and unlinked scenarios.

Utilizing Talk Station Radiology version 1.2 and AGFA Impax version 4.0, 15 plain film examinations per hour were read; with Talk Station Radiology version 2.1 and AGFA Impax version 4.1, 21 examinations per hour were reported; with Talk Station Radiology version 2.1 and AGFA Impax version 4.5, 26 examinations per hour were reported; with Talk Station Radiology version 2.1 and AGFA Impax version 4.5 with the systems linked, 32 examinations per hour were reported. This latter number, 32 examinations per hour, is slightly faster than the principal author's reading speed of 30 plain film examinations per hour utilizing an ordinary nonautomated viewbox and a dictating system. This, however, does not take into account the subsequent correction time for the reports returned by a transcriptionist. Two radiologists in the department of radiology are faster than the above reported times, but the majority are slower. An attempt was made to quantitate the number of plain film examinations per hour read

by each radiologist in the department, deriving the information from the RIS. However, not actually observing whether the radiologists were at their workstations during the survey periods, made this survey invalid. Accurate statistics on the number of examinations and relative value units (RVUs) per hour, per day, per month, or per year are available, but, as mentioned, hourly statistics are not an accurate reflection of work throughout on an hourly basis.

The linked system also reduces the potential for error. If an order exists for which there are no images, a situation that may arise if an examination is canceled while being undertaken, it will automatically enter an "exceptions file," which is managed by the Radiology Information Service personnel. This simple feature has reduced the number of cases being inadvertently reported for the wrong patient.

When the 2 systems operated separately, it was possible for a radiologist using 2 different patient worklists not to realize that a patient name in the speech recognition system did not have a corresponding file in the PACS containing images. If a radiologist dictated a report incorrectly, once the error was noted, whether by the radiologist himself, by the clinician, or by the Radiology Information System staff, it was time consuming to correct. If the problem was detected immediately, the report would be deleted by the Radiology Information System staff, and the radiologist would need to dictate the report again. If the error was discovered after the case was transferred from the short-term archive, it was necessary for the radiologist to add an addendum, a process that could take anywhere from 1 to 10 minutes.

With the linking of the PACS and the speech recognition system, clinical information is supplied without paper requisitions. The clinical information is transmitted automatically through the radiology information system to the PACS system header if it is generated by computerized ordering. This eliminates the very real potential for errors by our clerical staff from the misinterpretation of the content of paper requisitions. The hospital currently is in the process of converting the emergency room and inpatient areas to computerized ordering.

The technologists have a field in which they can enter comments such as "the patient could not stand for the upright film" located on the clinical

information display, which is superimposed on the first image to come up on the PACS display of demographics and clinical information so that this function does not have to be noted on a paper requisition.

#### CONTINUING CONCERNS AND EFFORTS AT CHANGE

Currently, the linked system is somewhat unreliable because the speech recognition system operates through the hospital information system, and from there the report is passed to the PACS system. Four major problems occur with the linkage: (1) The hospital information system periodically disconnects the speech recognition system from the PACS. (2) During peak hours of utilization of the hospital information system, the speech recognition system slows down. This is caused by heavy traffic on the hospital information system's network and typically occurs between 10:00AM and 3:00 PM (3) The speech recognition system occasionally "freezes up" so that it is impossible to dictate, to correct, to type corrections or to train the system to understand certain words. When the system freezes up, it is necessary to reboot both the speech recognition system and the PACS workstation. (4) The current linkage algorithm causes the dictations to be recorded on the hard drive of the speech recognition computer, in addition to entering the hospital information system. When the hard drive of the computer is full, the system slows and halts. This problem has been corrected by purging the accumulated reports from the local computer hard drive twice daily.

Efforts now are underway by the PACS vendor to bypass the hospital network system and link the speech recognition system directly to the PACS. This has been done with one of our experimental integrated workstations with equivocal results so far.

In addition to the technical changes, some of the radiologists themselves have modified their methods of dictation. One of the major defects in the existing speech recognition system is its failure to consistently and reliably transcribe single-syllable words. By emphasizing the pronunciation of these words, many of which are prepositions, the accuracy of the reports has improved. It has been proposed that the radiologists also go to the "train word" function whenever the speech recognition system fails to understand a word that is spoken

twice. Although on-the-job training of the speech recognition system disrupts workflow and creates discontinuity of the thought process associated with the examination being reported, the steadily increasing accuracy of the system offsets this.

### CONCLUSION

The ability of the PACS and speech recognition system to deliver diagnostic images and radiologists' reports in real time has made the radiologists' input into medical decision making of paramount importance within Elmhurst Hospital. The hospital's clinicians enthusiastically have endorsed the capabilities of the PACS and have become dependent on it.

Do the pros of utilizing a PACS and a speech recognition system within a large municipal hospital outweigh the cons? Despite the problems, our opinion is most definitely "yes!"

However, although the radiologists have found that image access to current and prior studies, and the ability of diagnostic workstation software tools to provide additional capabilities to manipulate images to facilitate diagnosis, the existence of the system has eliminated much needed clinician-to-radiologist communication. These dialogues provided insight into patient symptoms that assisted with diagnosis, and equally important, with necessary feedback. A conferencing mode within the PACS, which was designed to provide a more workflow-efficient substitute for face-to-face discussions is not being utilized by the clinicians. Ironically, the radiologists receive less information about patients as a result of the PACS implementation.

Some of the factors that would improve feedback to the radiologists include more interdepartmental conferences, utilization of all electronic ordering with insistence that reasonable clinical information be supplied in advance, and utilization

of the interactive conferencing mode that exists for the Web component of the PACS. The radiology department also is continuing its insistence that the quality assurance system of Elmhurst Hospital Center be changed to provide bidirectional feedback between the clinical and radiology quality assurance committees. All these changes are "doable"; it merely is a matter of hospital procedural implementation.

Very little has been published about the changes in communication protocols between radiologists and clinicians that are required when a PACS is implemented.<sup>8</sup> This is an area in which more formal research is needed as PACS technology proliferates.

Better reported is the fact that the productivity of radiologists is decreased when a speech recognition system is combined with, but not electronically linked to, a PACS. An understaffed department may not be able to handle adequately the increased workload of transcriptionist functions that a speech recognition system mandates. Fully electronically ordered examinations and elimination of paper requisitions will improve productivity, accuracy of information, and timeliness, because there will no longer be the possibility of paper requisitions being temporarily or permanently misplaced. Furthermore, the reliability of the speech recognition system and its linkage to the PACS will improve by installing it directly in the PACS circuits, which are redundant and adequately robust compared with the hospital information system. As speech recognition systems, RIS, and PACS evolve to become a single integrated unit that interfaces with electronic order requisition systems, the problems associated with use of these technologies will vanish, and radiologists will deliver diagnostic reports even more rapidly than is possible today.

### REFERENCES

1. Hayt DB, Alexander S, Drakakis J, et al: Filmless in 60 days: The impact of PACS within a large urban hospital. *J Digit Imaging* 14:62-71, 2001
2. Pomerantz SM, Protopapas Z, Siegel EL: PACS and the end user: A study in two demanding environments, in Siegel, EL, Kolodner, RM (eds): *Filmless Radiology*. New York, NY, Springer-Verlag, 1999, p 237
3. Melson DL, Brophy R, Blaine GJ, et al: Impact of a Voice Recognition System on Report Cycle Time and Radiologist Reading Time in Proceedings of the SPIE Conference on PACS Design and Evaluation—Engineering and Clinical Issues, San Diego, CA, Vol. 3339:226-236, February 1998
4. Gale B, Safriel Y, Lukban A, et al: Radiology report production times: Voice recognition vs. transcription. *Radiology Management* 23:23-25, 2001
5. Kanai KM, Hangiandreou NJ, Sykes AM, et al: Evaluation of the accuracy of a continuous speech recognition software system in radiology. *J Digit Imaging* 13:211-212, 2000 (suppl 1)
6. Ramaswamy MR, Chaljub G, Esch O, et al: Continuous speech recognition in MR reporting. *AJR* 174:617-622, 2000
7. Hundt W, Stark O, Scharnberg B, et al: Speech processing in radiology. *Eur Radiol* 9:1451-1456, 1999



8. Huang HK, Lou SL, Wong WK: PACS pitfalls and bottlenecks, in Proceedings of the SPIE Medical Imaging Conference, San Diego, CA, Vol. 3035:2-5, February 1997

9. Reiner B, Siegel EL, Protopapas Z, et al: Impact of filmless radiology on frequency of clinical consultations with radiologists. *AJR* 173:1169-1172, 1999

10. Pasko T, Seidman B: Physician characteristics and distribution in the US: 1996-1997 Edition. Department of Physician Practice and Communications Information, Division of

Survey and Data Resources. Chicago, IL, American Medical Association, 1996

11. Pasko T, Seidman B, Birkhead S: Physician characteristics and distribution in the US: 2000-2001 Edition. Department of Physician Practice and Communications Information, Division of Survey and Data Resources. Chicago, IL, American Medical Association, 2001

12. Sunshine JH, Bushee GR, Mallick R: U.S. radiologists' workload in 1995-1996 and trends since 1991-1992. *Radiology* 208:19-24, 1998