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The Evolving Role of the Radiologist within the Health Care System

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Abstract

The traditional view of the radiologist as a physician who adds value to the health care system solely by generating and interpreting diagnostic images is outdated. The radiologists' roles have expanded to encompass economic gatekeeping, political advocacy, public health delivery, patient safety, quality of care improvement, and information technology. It is through these roles that radiologists will continue to find new ways to add value to the healthcare system.

Keywords

Review; patient safety; information technology; preventative medicine; public health; cost containment; quality of care

Introduction

Over the last two decades there have been a series of changes in medicine, technology, and national healthcare funding that have significantly changed the role that the radiologist plays in the healthcare system. Recently, the effects of these changes have become more conspicuous secondary to the increasing legislative scrutiny of diagnostic imaging and the ever increasing impact of information technology on all aspects of health care. The traditional image of the radiologist as a physician whose role is to sit in a dark room interpreting films and generating reports has become outdated, if not obsolete.

While the topic of containing rising health care costs has long been an area of significant concern for the entire medical community, recent congressional action has significantly increased the attention focused upon diagnostic imaging. On February 1, 2006, the U.S. House of Representatives passed the Deficit Reduction Act (DRA) of 2005, a budget-cutting bill with provisions to significantly reduce Medicare reimbursement for imaging services[1]. While the Congressional Budget Office (CBO) estimates that the imaging provisions will save $2.8 billion over 5 years[2], the American College of Radiology's preliminary analysis indicates that these cuts could result in a $6 billion financial impact upon radiologists over 5 years[1].

There are two major provisions of the DRA which will effect radiologist reimbursement. Both provisions address the technical component reimbursement without affecting the professional

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component of reimbursemen[3]. The first provision, effective January 1st 2007, reduces the technical component of reimbursement for non hospital outpatient settings to the lesser of the Hospital Outpatient Payment System (HOPPS) or the Medicare fee schedule payment. Previously, the technical fee schedule for in office imaging was higher than that for the hospital setting in order to offset the costs of physician ownership of the equipment and the involvement of the staff in the service[4]. This provision does not affect outpatient imaging performed in the hospital setting. The second provision, effective January 1st 2007, reduced technical fee reimbursement for certain diagnostic imaging procedures on contiguous body parts by 25% in 2007 for non hospital based imaging[3]. This recent series of events underscores the need for the radiology community to remain politically active in order to insure the future of diagnostic imaging as an integral and viable component of the healthcare system.

This series of budget cuts was almost certainly influenced by the rapidly increasing costs of diagnostic imaging within federal healthcare budget. According to a recent article by Kirby, “imaging costs are far surpassing the growth of the other sectors, and costs near $100 billion annually, according to Medicaid and US Government Accounting Office data. Comparative analysis shows a three - fold discrepancy in the growth of medical imaging in relation to other medical services from 1999 to 2002, and a further increase by 16% in 2003[5]. While Medicare costs have increased by 30%, imaging costs have increased by 50%”[5,6]. While a significant portion of this increase can be attributed to imaging performed by non radiologists, there are several opportunities for radiologists to help prevent inappropriate and/or over utilization of diagnostic imaging.

Advances in imaging and information technology have increased the importance of the radiologist not only by increasing utilization of diagnostic imaging, but also by moving the radiologist into a more central role in integrated patient care.

Increased utilization of diagnostic imaging significantly affects utilization of funds, systems operations of a healthcare system, patient safety, and the system’s information infrastructure. Subsequently, the radiologist is assuming increasing responsibilities with respect to gatekeeping, quality of care improvement, patient safety, and information management.

In addition, advances in radiology are yielding more and better techniques for cancer screening. Therefore, radiologists are presented with new opportunities to expand their role as public health providers.

While image generation and interpretation remain central to the practice of radiology, the radiologist’s role in the integrated healthcare system has expanded to provide significantly more value to the healthcare system.

The Radiologist as Gatekeeper

While the term gatekeeper has traditionally been applied to primary care physicians, the radiologist can also have a role in insuring that medical resources are utilized efficiently and appropriately. A gatekeeper can be defined as a person who is positioned between an organization and the individuals who wish to utilize the resources within that organization[7]. While the primary care physician may be the patient’s first contact in the medical system, the radiologist often becomes involved in the initial diagnostic workup. Moreover, the results of the radiological examination may determine the need for additional diagnostic tests, specialist referral and/or hospital admission.

One of the methods that radiologists can use to facilitate the appropriate allocation of resources is clinician education [8,9]. Performing the appropriate exam can save the patient both the cost and the ionizing radiation associated with unnecessary/unindicated exams. Considering the rapid technological advances in radiology, regular clinicoradiographic meetings/lectures could greatly enhance the clinicians' ability to order the appropriate studies. While the majority of studies ordered by clinicians are appropriate, occasionally the radiologist may feel that there is a more suitable investigation for the clinical question. Communicating this concern to the ordering clinician can result in the collaborative selection of the appropriate study and a learning opportunity for both parties[8]. This type of collaboration between radiologists and clinicians can be taken a step further by jointly developing clinical decision rules or guidelines for imaging[9].

The gate keeping strategies outlined in the previous paragraph are, unfortunately, time intensive and, in the case of contacting a clinician regarding the ordering of an inappropriate study, not proactive. Improving the process by which studies are ordered and interpretations are rendered has the potential to significantly improve resource utilization without ongoing radiologist input. To this end, increased utilization of information technology holds promise for reducing the overall cost of imaging in the integrated health care system. Simply by having reports easily available, clinicians can know which exams have already been done and unnecessary repeat examinations can be avoided[10]. Implementation of a computerized order entry system could assist clinicians to order the appropriate studies. For example, integrating a decision support program, that would allow clinicians to enter a diagnosis or keyword and generate a list of appropriate imaging studies, could not only improve utilization but also decrease the amount of time spent contacting clinicians regarding inappropriate studies. Such an application could be based on the American College of Radiology (ACR) appropriateness criteria. In addition, computerized order entry can provide data on the ordering patterns of different providers and clinics. This data could then be used to ascertain whether or not imaging is being used appropriately and who would benefit most from clinicoradiographics meetings/lectures. Such a program has already been introduced in the Kaiser Permanente Northwest Computer-Based Patient record system[9].

The radiologist can also assist the primary care physician in their gatekeeping role not only by recommending appropriate imaging follow up but also by sometimes recommending the appropriate referrals to specialists[8].

Self-referral can greatly increase the utilization of diagnostic imaging and the associated costs. Hillman *et al.* found that depending on the clinical presentation, self-referral to one's own imaging facilities resulted in 1.7 to 7.7 times more frequent performance of imaging examinations than referral to radiologists[10]. Maitino, A *et al.* demonstrated that between 1993 and 1999 the utilization of noninvasive diagnostic imaging in the Medicare fee-for-service population increased 3.8% with respect to the total number of examinations performed while the amount of work associated with the imaging, i.e. the relative value units (RVUs), increased by 14.6% in the same population[11]. During this same time period, the overall utilization/total number of studies of noninvasive diagnostic imaging decreased 3.9% among radiologists but increased 25.2% among nonradiologists [12]. In addition, between 1993 and 1999, the overall RVU rates increased 6.9% among radiologists and 32.4% among nonradiologists[12]. Therefore, while imaging referred to radiologists by other physicians is one cause of increased imaging utilization, nonradiologists who can self-refer to their own facilities are more rapidly increasing imaging utilization[10,13].

Radiologists are relatively limited in their ability to refer patients to their own facilities. Congress passed the Stark I law in 1989 and the Stark II law in 1993, in general, these laws prohibit physicians from billing Medicare for designated health care services provided to patients who are referred to a facility in which physician or an immediate family member has a financial interest[5,13]. While the majority of diagnostic imaging is covered by these laws, nuclear medicine examinations are not. In addition, there is a loophole in the law that allows self-referral for in-office diagnostic imaging. It is these loopholes that allow for non radiologists to self-refer imaging and this can result in increased utilization[5]. Since the majority of radiologists rely upon referrals, utilizing radiologist as the diagnostic imager has the potential to substantially reduce the costs associated with diagnostic imaging. Therefore, the radiologist can reduce health care by avoiding self-referral and acting as the principle physician involved in the performance and interpretation of diagnostic imaging studies.

Radiologists can also reduce costs the costs of unnecessary imaging by avoiding a practice that has come to be known as self-dealing[14]. Self-dealing occurs when a referring physician makes money, directly or indirectly, by a referring a patient for a medical imaging procedure [14]. The referring physician typically gains financial benefit by billing for the technical component of the procedure, because the referring physician either owns the equipment or leases time on the equipment from an otherwise independent imaging provider[14]. With such a financial incentive, the referring physician may increase their ordering of diagnostic imaging services beyond their usual level of utilization. By avoiding self-dealing, radiologists can help to reduce the risk of financially motivated increases in diagnostic imaging.

The Radiologist as Political Advocate

Radiologists can also help contain increasing healthcare costs by influencing policy decisions of private payers and the government. The American College of Radiology (ACR) is actively involved with both private payers and the government. For example, in 2004, United Health Care consulted with the ACR to implement imaging protocols for more than 190 conditions [15]. The Government Relations (GR) department of the ACR has staff who attend numerous fundraisers throughout the year to speak with the congressmen and congresswomen who will ultimately influence public health policy[16] Actively campaigning to close loopholes in the Stark laws has the potential to significantly reduce total imaging costs within the United States. In addition, the GR staff represent the interests of radiologists at meetings such as the AMA [16]. In 1999, the ACR formed RADPAC whose goal is to support and elect pro-radiology candidates at the federal level through the voluntary contributions of members of the American College of Radiology Association (ARCa)[16].

At the national level, there are two major policy issues which are driving increased utilization of diagnostic imaging: self-referral and defensive medicine[5,15–17] It is estimated that at least $100 billion of the United States $1.7 trillion annual health care bill is defensive medicine to avoid potential malpractice litigation[15]. Defensive medicine can drive physicians to order medically unnecessary imaging to establish a medical record in case of a lawsuit[15]. Tort reform has the potential to reduce the ordering of “protective imaging”[15]

The American College of Radiology is actively supporting the recommendations of the MEDPAC (Medicare Payment Advisory Commission) which promote imaging quality standards for both interpreting physicians and the imaging facilities which would eliminate many low quality or marginal imaging studies from being performed[16]. This is projected to save $4–6 billion[16]. These savings are likely to be secondary to decreased self-referral and decreased repeat imaging for inadequate studies[16].

Some authors have proposed even greater action to contain self-referral and the costs associated with the over utilization of diagnostic imaging[18]. Levin and Rao, have advocated several steps that could be implemented to contain or reduce the over utilization of noninvasive diagnostic imaging. They advocate stiffer laws against self-referral to close the in office exemption in the Stark laws[18]. Like the ACR and MEDPAC, they advocate mandatory accreditation of imaging facilities which could force many providers of low quality or marginal studies out of business[18]. Restriction of imaging privileges for non radiologists, precertification/ preapproval of self-referred imaging studies, and paying only the technical fee for self-referred studies could also reduce the amount of self-referred studies. Levin and Rao also advocate the institution and enforcement of certificate of need laws at the state level [18]. Requiring higher co-payments for imaging studies may raise the threshold for physicians and patients to pursue imaging tests[18]. While these steps could help contain rising health care costs, they would almost certainly encounter stiff resistance from the larger medical community[16].

The Radiologist as Public Health Provider

Generally considered the domain of the primary care provider, public health encompasses a range of topics including immunizations, cancer screening, and other key health care services for reducing morbidity and mortality in the population. While radiologists are certainly involved in public health/ preventative medicine (e.g. breast and colon cancer screening), it is not immediately obvious that the radiologists' practice can be used as a vehicle to encourage increased adherence to cancer screening. Admittedly, radiologists do not have the longitudinal patient-physician relationships that give primary care physicians the opportunity to foster preventative health behaviors in their patients[19]. Fortunately, there are naturally occurring life transitions or health events that are believed to motivate individuals to adopt risk-reducing health behaviors[19,20]. These events have been termed "teachable moments"[19,20].

The concept of the "teachable moment" can be applied to the radiologist's practice and may directly or indirectly serve as a method to improve quality of care by enhancing healthy lifestyles or by improving adherence to other screening tests[21]. For example, mammography could be considered a "teachable moment" for educating patients about the risk of colon cancer and encouraging colorectal cancer screening[21]. Rates for colon cancer screening lag behind those of breast, cervical, and prostate cancer[22]. Further, women participate in colorectal cancer screening at a rate lower than men[21]. The American Cancer Society estimates that there will be approximately 106,608 new cases of colon cancer and 41,930 new cases of rectal cancer in 2006; therefore increasing the rates of colorectal cancer screening among women could have a significant impact on public health[23].

While productivity pressures and the absence of an existing patient-physician relationship preclude the radiologist from personally assessing and counseling each patient, changes could be made in the diagnostic radiology encounter without significant changes in infrastructure or staffing[21]. For example, the patient could fill out a brief questionnaire regarding adherence to cancer screening behaviors prior to their mammogram. Patients who require additional cancer screening services could then be given pertinent educational material. Such a model is not without precedent. Patients routinely are asked to fill out forms that answer demographic and health-related questions prior to other medical appointments. In addition, a recent meta-analysis by Stone et al. demonstrated that organizational changes in clinical procedures, infrastructure, redesign of jobs, and facilities was consistently more effective that physician-directed or patient directed educational efforts for promoting adherence to cancer screening [24].

Cancer screening could be further facilitated by the development of centralized screening "cores"[21] Women's health imaging cores offering screening mammography, bone density screening, and ultrasound already exist. If CT colonography, CT lung cancer screening, and/or coronary calcium scoring are ever approved by the government or insurance companies, then a CT scanner could be added to such a facility. The familiarity of such a clinical setting would increase the convenience and potentially decrease the personal cost of screening; two factors that are cited as important predictors of adherence to cancer screening[25].

In addition, utilization of information technology could also increase the efficacy of such imaging cores without requiring significant additional costs in labor or infra-structure[21].

Software could be adapted to detect nonadherence with health screening and subsequently electronically notify the primary care clinician. Other ways to use information technology include pop-up displays of needed services at the patient's next appointment or automated generation of patient reminders similar to screening mammography.

Increased involvement of the radiologist in promoting cancer prevention/early detection offers a number of potential benefits. In addition, using existing imaging tests to successfully promote cancer prevention increases the underlying value of the imaging test and may improve the cost-effectiveness of the original test. For example, successful application of the screening mammography encounter as a teachable moment for colon cancer screening may further improve the cost-effectiveness of screening mammography programs after accounting for decreased colon cancer morbidity and mortality. Finally, adoption of such preventive medicine initiatives within the radiology department can foster a more collaborative relationship with primary care physicians that will likely demonstrate an important "added value" of radiographic services[21].

The Radiologist as Safety Officer

Increased utilization of computerized tomography (CT) has been a major factor in the renewed interest in radiation safety. Increases in both the availability of multidetector row CT scanners and the number of clinical indications for CT has caused explosive growth in CT utilization [27]. Subsequently, much of the recent emphasis in the radiation safety literature has focused on reducing patient dose from CT scans[27–29]. In the last decade, there has been increased emphasis on improving patient safety within the health care system. Many of these new patient safety initiatives can be attributed to increased awareness of the national impact of medical error in conjunction with the development of the "systems approach" to medical error which strives to develop systems and policies that prevent medical errors or at least mitigate their effects.

In a survey performed in 2000–2001, it was estimated that 50–65 million CT examinations were performed in the United States each year[29]. Consequently, CT scanning is now the major man-made contributor of radiation dose to the general population[27,29]. Fortunately, there are several strategies for reducing patient dose while maintaining image quality appropriate for the clinical indication of the CT scan.

The strategies for reducing the radiation dose associated with CT scans can be divided into two major categories: clinical and technological[27]. Clinical methods for CT dose reduction involve changing the CT protocol for a specific patient or clinical indication. Technological strategies for CT dose reduction involve changes in software and hardware which decrease radiation dose.

Clinical strategies for the reduction of CT dose can be implemented by the radiologist. Performing CT scans only on patients with appropriate clinical indications can save the patient both cost and radiation exposure[27]. Follow-up or repeat CT scans can be limited to the area with pathologic findings[27]. When possible, alternative imaging modalities such as magnetic resonance imaging or ultrasound should be utilized[27]. Customizing the tube current for patient size can significantly reduce patient dose, especially in the pediatric population[27, 28]. Depending on the clinical indication, tube current can be reduced, while pitch, slice thickness, and spacing can be increased to reduce patient dose[27,28]. For example, lung nodule screening, CT colonography, and renal stone CT can be performed at significantly lower doses than standard CT and still be able to detect the disease entities specific to the respective indication[27]. Reducing the number of phases in a study can also reduce the dose. For example, the number of phases in CT urography can be reduced by utilizing a split bolus. The split bolus administers part of the intravenous contrast dose and then, after a delay, the remainder of the bolus is administered. Subsequently, the first portion of the bolus is in the renal collecting system and the second portion of the bolus is in the nephrographic phase. Nephrographic and excretory phase imaging are then performed at the same time instead of having to perform successive nephrographic and excretory phase scans. Tube current can also be reduced for many interventional procedures where image quality is not as critical as it is for diagnostic procedures[27].

Technological strategies for radiation dose reduction are generally implemented by CT manufactures. While many innovations have been made to reduce the patient's radiation dose, one of the most significant advances has been in dose modulation[27]. This method involves altering the tube current with respect to the anatomic area being scanned. For example, in CT coronary angiography, the coronary arteries are best seen in late diastole. The CT current/ patient dose can subsequently be reduced during systole without significantly compromising the images of the coronary arteries when the images are reconstructed. The choice of a noise reduction reconstruction filter can also indirectly affect patient dose by reducing the noise in images from low dose CT scans[27,28]. Technological strategies are certainly an important part of improving radiation safety, and should be considered when purchasing software and equipment. During day to day practice, the role of the radiologist is to utilize clinical strategies to reduce patient dose to levels as low as reasonably achievable (the ALARA principle) while maintaining diagnostic quality images.

Within the past decade, there has been an increased emphasis on improving the quality and safety of health care. While radiation safety and contrast administration have traditionally been perceived as the radiologist's contribution to patient safety, increased attention has focused on the prevention of medical errors. Recognition of a medical error as a product of multiple small failures in a system of care, rather than a single act, has led away from identifying the individual who made "the mistake" and toward the identification of the characteristics of the system that may have contributed to the suboptimal outcome[30,31]. While the majority of the radiology literature on the systems based approach focuses on the prevention of medical error, the continuous quality improvement literature also applies the systems based approach to improving the day to day function of a radiology department and this will be discussed in the next section[31].

Much of the current interest in applying the systems approach to medical error can be linked to a 1999 Institute of Medicine report estimating that medical error kills 44,000 to 98,000 people a year in U.S. hospitals[32]. Much of the groundwork of the systems approach to human error in medicine was derived from earlier investigations by psychologists of "high reliability organizations," defined as institutions that perform complex technologically demanding tasks under significant time pressures and very high peak demand[31]. Specifically, U.S. Navy nuclear aircraft carriers, nuclear power plants, and air traffic control centers were studied [31]. These systems strive to anticipate the worst and equip themselves at all levels of the organization to deal with adverse events. These organizations strive to make their system as robust as possible in the face of human fallibility and operational hazards.

This strategy for error prevention differs from the traditional "person approach" to error prevention traditionally utilized in medicine and many other fields[31]. The person approach to error management focuses on identifying an individual who performed the unsafe act or procedural violation[31]. It attributes these unsafe acts to aberrant mental processes or poor moral character (e.g. forgetfulness, inattention, carelessness, negligence, and recklessness). Efforts to prevent human error are directed at changing variability in human behavior through methods such as poster campaigns, adding additional policies, retraining, threat of litigation, and blaming[31]. Such an approach can offer a short term advantage for managers and institutions by uncoupling a person's acts from institutional responsibility. Unfortunately, such an approach can be detrimental to the development of safer health care. People are unlikely to report potential hazards and near misses if they fear reprisals[31]. Subsequently, it becomes far more difficult to anticipate and correct potential sources of medical error prior to an adverse event.

The systems based approach to error prevention assumes that humans are fallible and prone to errors; therefore systems must be designed both to prevent errors and when errors occur to mitigate their effects[31]. There are two major categories of errors: active errors and latent errors. Active error occurs when unsafe acts are committed by persons in contact with patients or the system, while latent error represents failures of system design[33]. A general rule of thumb in continuous quality improvement thinking is that 85% of errors in a system are latent and only 15% of errors are active[30]. An example of a latent error in radiology would be a dimly lit view box in a mammography department. It alone poses no immediate threat to patient safety, but it could certainly contribute to a missed diagnosis and significant subsequent morbidity and mortality. This view box would also be an example of an “upstream” systemic factor that could contribute to an adverse event.

While the systems based approach to error management/ patient safety has many potential applications in radiology, much of the literature for applying these methods has focused on the notification of the referring clinicians. This phenomenon is in part likely secondary to patterns in plaintiff filing of malpractice cases. Failure of communication and communication breakdowns have been reported in 70 to 80% of depositions obtained on plaintiffs’ malpractice cases[34]. In addition, failure of communication of an emergent or unexpected finding can result in significant adverse events. The clinical importance of communication is also affirmed within the American College of Radiology Standards of Communication which states in part:

“Routine reporting of imaging findings is communicated through the usual channels established by the hospital or diagnostic imaging facility. However, in emergent or other non-routine clinical situations, the diagnosing imager should expedite the delivery of a diagnostic imaging report (preliminary or final) in a manner that reasonably ensures timely receipt of the findings”[35].

Complying fully with the ACR standards of communication can be difficult to achieve but recent literature has utilized the systems approach to facilitate this process and prevent adverse events[36].

Recent articles by Choksi et al, outlined a method for instituting a semi-automated coding and review process for notification of unexpected findings suggestive of malignancy[36]. The impetus for developing this notification system was a near miss or “sentinel event” in a case where multiple lung nodules were found on a patient’s preoperative chest x-ray. These findings were suspicious for metastatic disease and the referring clinician was subsequently informed via telephone. Unfortunately, additional work up was not performed, because of a series of communication errors. Subsequently, the patient had another chest x-ray in a later admission. Fortunately, longitudinal comparison of several prior plain films, not previously available, revealed these findings to be stable and likely the sequela of old granulomatous disease[33].

To capitalize on this near miss and enact systems changes to improve patient safety, a root cause analysis was performed to identify the reasons why the system failed and what factors contributed to create the conditions in which the error occurred[33,37,38]. Results from this analysis led to the institution of a mandatory radiology report coding and periodic review of reports coded as “unexpected finding, probable malignancy”[33]. This new policy used a multidisciplinary approach to manage care. After the radiology coding, the hospital’s Cancer Registrar monitored for appropriate follow up of possible malignant findings and reported cases that were not followed up within two weeks to the hospital's tumor board. This system change made for a safer environment by adding an additional level of redundancy with only nominal additional cost[36].

The Radiologists and Continuous Quality Improvement

The continuous quality improvement (CQI) literature emphasizes systems orientation and patient safety, but also seeks to apply lessons from operations research and industrial management to multiple other aspects of health care[30]. CQI methods have been widely adopted by administrators but are a relatively new concept within the radiology literature [30]. Although a full discussion of CQI is beyond the scope of this paper we will attempt to familiarize the reader with some of the basic concepts. If further information is desired, the article by Applegate in the references provides an excellent resource. CQI is defined as "the ongoing, organization-wide framework in which employees are committed to and involved in monitoring and evaluating all aspects of an organization's activities (inputs and processes) and outputs to continually improve them"[30]. The key features of CQI are customer-mindedness, data collection, experimentation, and team work[30]. Like the systems approach to error management, CQI methods attempt to anticipate problems rather than react to them. Current quality assurance programs are typically seen as a more reactive form of management and this is why, in 1991, the JACHO formulated a plan to move hospitals away from QA to CQI.

The implementation of CQI methods occurs in a series of steps. The first step is to find a process to improve. The second step is to organize a team who skills are relevant to the problem (preferably an interdisciplinary team composed of people with different training and professional backgrounds). The third step is to study a process by analyzing the series of steps in that process and collecting data on each of those steps (note: this part of the CQI method is very similar to the aforementioned root cause analysis). The fourth step is to select a way to improve the process and implement that improvement. The fifth step is to repeat the entire process; hence the term continuous quality improvement.

Where CQI methods diverge from many current management decisions in health care is that the improvements made should be small and be part of an ongoing process. This is quite different from the common practice of assembling a committee to address a problem and move on to the next topic once the appropriate changes have been agreed upon. The mantra of CQI appears to be "start small, start early, and keep working on it"[30]. Small changes instituted by interdisciplinary teams seem to better received and implemented than large changes imposed by people from a different discipline or background.

Currently there is little literature to support the efficacy of CQI methods in radiological practices, but, considering its similarities to the systems based error management literature, these concepts hold promise for the future practice of radiology. A theoretical application of CQI could be performed in an MRI imaging center where a team of receptionists, physicians, nurses, and technologists could be brought together to address scanner turnaround time between patients. Multiple small problems, such as illegibility of protocols written by physicians, patients arriving in the MRI suite without appropriate IV access, and problems with patient registration, could be identified. Each of these problems could be addressed and, through a series of small incremental improvements, a far more efficient system for utilization of the MRI scanners could evolve. In addition, the resultant improvements in team communication and coherence would facilitate future CQI endeavors.

The Radiologist as Information Technologist

It was not long ago that the vast majority of radiologists read off of film, dictated reports to human transcriptionists, and sent their reports on paper to the referring clinicians. Many such practices still exist today, but the role of information technology in the practice of radiology is rapidly changing.

Although digital imaging (i.e. ultrasound, CT, and MRI) has been part of radiological practice for decades, picture archiving and communications systems (PACS) are a relatively recent development with the potential to greatly impact many aspects of a radiological practice: "PACS are often complex and costly to acquire, replace, maintain, or repair. Furthermore, the performance of PACS can directly affect patient care and clinical flow"[39]. Other information technology developments such as computerized dictation and programs for physician notification can also have significant effects on not only work flow but also the referring clinicians' expectations of service[32]. Considering the increasingly central role that information technology is playing in all of medical practice, radiologists must be able to understand and manage information technology if they wish to remain clinically relevant.

Advances in CT and MRI scanners have resulted in a significant increase in the number of images per study[40]. It is neither practical nor cost effective to read 1000 or greater image studies off of films hung on alternators. Subsequently, a PACS system must be adopted to read these newer studies.

Literature on the factors that need to be considered when purchasing a PACS system exists [39]; this paper will discuss how a PACS system can affect clinical work flow and interactions with clinicians.

A properly functioning PACS system can significantly enhance radiologist productivity and clinician access to images. There are opportunities for significant time and cost savings associated with no longer having to print or hang film. In addition, images can be distributed almost instantaneously to multiple locations, dramatically enhancing clinician access. A properly functioning PACS can also increase productivity and report turnaround time by rapidly retrieving comparison studies. In addition, electronic storage of images has the potential to improve patient care by reducing the number of lost images. The functionalities of the display workstations can also enhance productivity by retrieving pertinent reports, hanging images in accordance with the reader's preferences, and processing images to maximize disease detection (i.e. preset CT windows and levels). With the expected continued decreases in the costs associated with processor speed and information storage, the performance-to-cost ratio of PACS is only expected to continue to improve[39].

Unfortunately, PACS are complex systems that can have catastrophic effects on patient care and work flow when they malfunction. There are at least three and up to five information systems in a radiology department that are required to handle the data associated with one examination[39]. These systems include the hospital information system (HIS), the radiology information system (RIS), PACS, the voice recognition system, and the electronic teaching file system. In addition, there must also be integration of PACS with the different imaging modalities (CT, MRI, etc.) and the enterprise distribution (clinician viewing stations). The system is further complicated by the fact that the PACS system operates with a Digital Imaging and Communications in Medicine (DICOM) system while the RIS and HIS systems utilize a Health Level 7 (HL7) system; therefore, many systems require a broker to allow for communication between the PACS and the RIS. The level of complexity of a PACS system and the potential for catastrophic system failure underscore the importance of performance testing and verifying preventative maintenance and local support service prior to purchasing a PACS system[39].

Even when properly functioning, PACS has the potential to erode the perceived value of the radiologists in the eyes of the clinicians and the health care system. Enterprise distribution of images reduces the need for clinicians to directly consult a radiologist if they want to view the films. The advent of filmless interpretation and computerized dictation can dramatically reduce report turnaround times and further reduce the need for radiologist-clinician interaction. Subsequently, there is the risk that the radiologist will become a faceless entity with diminished perceived value within the health care system[32].

Fortunately, advances in information technology also have the potential to significantly enhance the radiologist's role in integrated patient care. As mentioned earlier in this paper, information technology can help facilitate the radiologist's role as a public health provider by facilitating the identification and scheduling of patients in need of screening exams[21]. In addition, information technology can enhance the role of the radiologist as a safety officer. Information technology can be used to track patients with findings suspicious for cancer and confirm they receive follow up[36]. Another exciting possibility is the utilization of existing PACS systems to store non radiologic/ "visible light" images such as images from endoscopy of histology[41,42]. This would allow radiologists to leverage their robust image archiving and distribution systems in other departments[41,42]. Sharing these resources could reduce operational costs in the integrated healthcare system, while increasing radiology's overall relevance as the information technology specialists in healthcare.

While advances in information technology may have some negative affects on the perceived value of the radiologist, the same technology can also be used to expand the added value of the radiologist.

Conclusions

The traditional view of the radiologist in a dark room in front of a view box and adding value to the health care system solely by interpreting images is rapidly becoming outdated. While advances in imaging technology, especially CT and MRI, have expanded radiologist's diagnostic capabilities, the value of the radiologist has also expanded outside of image interpretation. Advances in information technology have the potential to make the role of the radiologist more central in the overall systems operation of the health care system; specifically by providing more immediate clinically relevant information, enhancing patient safety, and improving public health/cancer screening. In addition, radiologists can perform a gatekeeper role by significantly reducing imaging costs resulting from the ordering of inappropriate and/ or self-referred studies.

While the roles described above have the potential to increase the relevance of the radiologist in the health care system, currently, there is little short term incentive for the radiologist to engage in them. Moreover, clinical productivity pressures and, in the case of information technology, significant start up costs can actually discourage the radiologist from engaging in these roles.

In order to enable radiologists to effectively implement these roles they must have adequate education, time, and resources. The introduction of pay for performance in medicine represents an opportunity for radiologists to redefine their professional roles and to possibly include these roles in their definition of quality of care[43]. Subsequently, performing these roles could be included in a pay for performance metric and provide financial incentive for the investment of the necessary time and effort. Education on developments in patient safety, continuous quality improvement, cost containment, and information technology could be added to residency and fellowship training programs. Considering the recent scrutiny on imaging costs and patient safety, it would benefit radiologists to take a proactive approach to address these issues and to establish standards before law makers and insurance companies are compelled to make their own determinations on these matters.

Several themes have emerged in this paper: the importance in increasing clinician interaction, the importance of participation in the health care system and political action committees, and the need to embrace information technology. It is through these mechanisms that radiologists will continue to find new ways to add value to the healthcare system and remain clinically relevant.

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