Effect of Filmless Imaging on the Utilization of Radiologic Services[1]

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Abbreviation:
PACS = picture archiving and communication system

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PURPOSE: To determine the effect of a large-scale picture archiving and communication system (PACS) on in- and outpatient utilization of radiologic services.

MATERIALS AND METHODS: Data were collected at the Baltimore Veterans Affairs (VA) Medical Center (BVAMC) before and after implementation of an enterprise-wide PACS; the numbers and types of imaging examinations performed for fiscal years 1993 and 1996 were evaluated. These data were compared with those from a similar academic medical center, the Philadelphia VA Medical Center (PVAMC), and with aggregate data obtained nationally for all VA hospitals over comparable periods.

RESULTS: Inpatient utilization, defined as the number of examinations per inpatient day, increased by 82% (from 0.265 to 0.483 examinations per patient day) after a transition to filmless operation at BVAMC. This is substantially greater than the increases of 38% (from 0.263 to 0.362 examinations per patient day) and 11% (from 0.190 to 0.211 examinations per patient day) at the film-based PVAMC and nationally, respectively. Outpatient utilization, defined as the number of examinations per visit, increased by 21% (from 0.108 to 0.131 examinations per visit) at BVAMC, compared with a 1% increase (from 0.087 to 0.088 examinations per visit) at PVAMC and a net decrease of 19% (from 0.148 to 0.120 examinations per visit) nationally.

CONCLUSION: The transition to filmless operation was associated with increases in inpatient and outpatient utilization of radiologic services, which substantially exceeded changes at PVAMC and nationally over the same interval.

A detailed understanding of the utilization of radiologic services is important for a number of reasons, including the process of planning for equipment, personnel, and other resources and the negotiation of contracts, particularly with managed care providers. There are a number of prior studies that cover various perspectives on utilization, but to our knowledge these all deal with a traditional film-based environment (1–4). Burkhardt and Sunshine (5) evaluated population-based utilization rates for all patients enrolled in medical care programs, regardless of their utilization of medical services. In other studies (6,7), global imaging utilization trends were not evaluated, and the focus was exclusively on inpatient or outpatient data.

With the advent of filmless imaging, a number of operational improvements have been reported, including better image management with fewer lost and unread images, the ability to provide almost "real-time" interpretation with decreased report turnaround times, and greater image and report accessibility (8–10). These operational improvements have the potential to create a more "customer-friendly" imaging department with increased utilization of imaging services. On the other hand, the improved image management and access to previous images and reports could decrease the need to perform additional, possibly redundant examinations.

This study was undertaken to identify and analyze the change in the utilization of imaging services after the transition to an enterprise-wide picture archiving and communication system (PACS) for both inpatient and outpatient examinations.

TABLE 1
Change in Total Number of Examinations and Weighted Work Units between 1993 and 1996

Parameter	Baltimore			Philadelphia			National		
	1993	1996	Percent Change	1993	1996	Percent Change	1993	1996	Percent Change
Total no. of examinations	36,563	54,201	48	44,777	53,049	18	6,328,136	5,830,370	−8
Total weighted work units	123,957	209,502	69	123,354	170,301	38	18,428,117	19,044,436	3
Mean weight per examination	3.39	3.87	14	2.75	3.21	17	2.91	3.27	12

MATERIALS AND METHODS

The study population consisted of all patients treated within the Veterans Affairs Medical System for the fiscal years 1993 and 1996. Data were collected at the Baltimore, Md, and Philadelphia, Pa, Veterans Affairs Medical Centers and for all 172 Veterans Affairs Medical Centers in the National Veterans Affairs database.

After installation of a large-scale PACS at the Baltimore Veterans Affairs Medical Center late in fiscal year 1993, the medical center made the transition to nearly filmless operation. Consequently, data obtained at the Baltimore Veterans Affairs Medical Center prior to the transition to filmless operation in 1993 were compared with data obtained after more than 2 years of experience with PACS in 1996.

Both the Philadelphia Veterans Affairs Medical Center and the National Veterans Affairs Medical System as a whole (except for Baltimore) were still film-based in 1996. The Philadelphia Veterans Affairs Medical Center was chosen as a control site due to similarities with the Baltimore Veterans Affairs Medical Center in patient demographics, academic affiliation, geographic location, and volume of studies.

Data for imaging services were collected from radiology workload data reports available on the automated management information system at local and national levels. The data evaluated included the frequency of examinations (collectively and individually by modality) and weighted work units. As defined by the Veterans Affairs Medical System, 1 weighted work unit equals 8 minutes of technologist time in the performance of an imaging procedure. Because of the Veterans Affairs data collection process, individual statistics on mammography and magnetic resonance (MR) imaging were not available on an individual basis and were collectively placed into a separate category designated "other." Individual data were available for general radiology, fluoroscopy, computed tomography (CT), ultrasonography (US), and special procedures.

TABLE 2
Percent Change in Volume of Examinations per Imaging Modality between 1993 and 1996

Modality	Baltimore		Philadelphia		National	
	Inpatient	Outpatient	Inpatient	Outpatient	Inpatient	Outpatient
General radiology	10	21	4	13	−19	−9
Fluoroscopy	−6	21	−3	37	−35	−13
Special procedures	58	731	45	509	33	128
US	94	110	−55	128	−3	38
CT	31	79	38	30	−10	24
Other	136	515	166	819	27	74
All	29	62	7	30	−15	−2

Note.—Data for nuclear medicine are not included.

The radiology data were correlated with inpatient census and outpatient data available from the medical administration service workload reports at both local and national levels. The outpatient utilization ratio was calculated by dividing the number of outpatient examinations by the number of outpatient visits, and the inpatient utilization ratio was calculated by dividing the number of inpatient examinations by the number of hospital days.

RESULTS

During the interval between 1993 and 1996, the National Veterans Affairs Medical System experienced an 8% decrease in examinations and only a 3% increase in the number of weighted work units (Table 1). At the Baltimore Veterans Affairs Medical Center, there was a 48% increase in the total number of examinations and a 69% increase in total weighted work units in 1996 as compared with 1993. In comparison, the increase in examinations was 18% at the Philadelphia Veterans Affairs Medical Center, with a 38% increase in the total weighted work units during the same interval.

The percentage of general radiologic examinations decreased for each of the three systems studied, with the decrease in the proportion of general radiologic examinations greater for outpatients than for inpatients. There was a shift nationally in the percentage of studies performed as general radiologic studies from 78% to 75% for inpatient studies and from 79% to 73% for outpatient examinations. After the transition to filmless imaging, Baltimore experienced the largest shift away from general radiologic studies, with a 19% decrease from 75% to 56% for outpatient examinations. There was a 10% decrease in the percentage of general radiologic inpatient examinations at Baltimore from 70% to 60%.

Nationally, there was an overall decrease in radiologic examinations of 15% for inpatient studies and 2% for outpatient studies (Table 2). The largest increase nationally was for special procedures, with a 33% increase for inpatient procedures and a 128% increase for outpatient procedures. The other area of increase nationally was for "other" examinations, which included MR imaging and mammography. The modality with the greatest decrease in the number of examinations nationally was fluoroscopy, with a 35% decrease for inpatients and a 13% decrease for outpatients.

The overall volume of imaging examinations increased at the Baltimore Veterans Affairs Medical Center by 29% for inpatients and 62% for outpatients. At the Philadelphia Veterans Affairs Medical Center, there was a 7% increase in inpa-

TABLE 3
Comparison of Inpatient and Outpatient Utilization for Fiscal Years 1993 and 1996

Parameter	Baltimore			Philadelphia			National		
	1993	1996	Percent Change	1993	1996	Percent Change	1993	1996	Percent Change
No. of inpatient examinations	14,799	25,365	71	22,425	24,098	7	2,885,264	2,439,563	−15
No. of outpatient examinations	21,764	34,706	59	22,352	28,951	30	3,442,872	3,390,807	−2
No. of hospital days	55,889	52,480	−6	85,264	66,594	−22	15,206,687	11,563,835	−24
No. of hospital admissions	5,479	6,560	20	7,226	6,110	−15	910,580	803,044	−12
No. of outpatient visits	200,861	264,640	32	255,669	328,059	28	23,314,000	28,360,000	22
Mean length of stay (d)	10.2	8.0	−22	11.8	10.9	−8	16.7	14.4	−14
Inpatient utilization									
Examinations per patient day	0.265	0.483	82	0.263	0.362	38	0.190	0.211	11
Examinations per admission	2.70	3.87	43	3.10	3.94	27	3.17	3.04	−4
Outpatient utilization: examinations per visit	0.108	0.131	21	0.087	0.088	1	0.148	0.120	−19

tient volume and a 30% increase in outpatient volume during the same interval.

Although there was a 15% decrease in inpatient examinations nationally, there was an 11% increase in inpatient utilization (examinations per patient hospital day) (Table 3). This is in contrast to a 19% decrease in outpatient utilization nationally, which accompanied the 2% decrease in total outpatient examinations. It is interesting that there was a major increase of 82% in inpatient utilization at the Baltimore Veterans Affairs Medical Center in comparison with a more modest increase of 38% at the Philadelphia Veterans Affairs Medical Center.

Alternatively, one can define inpatient utilization as the number of inpatient examinations per hospital admission (Table 3). Nationally, there was a 4% decrease in "per stay" (examinations per admission) inpatient utilization in comparison with a 43% increase at the Baltimore Veterans Affairs Medical Center and a 27% increase at the Philadelphia Veterans Affairs Medical Center.

The utilization of outpatient imaging services nationally was initially 0.148 examinations per visit and decreased to 0.120 examinations per visit during the study period, which resulted in a net decrease of 19%. The outpatient utilization also increased substantially in Baltimore during the interval between 1993 and 1996 by 21%, as compared with a 1% increase in Philadelphia (and the 19% decrease nationally). Inpatient utilization nationally increased 11% from 0.190 to 0.211 examinations per patient hospital day. During the same period, Baltimore's inpatient utilization increased 82% from 0.265 to 0.483 examinations per patient day. Outpatient utilization in Baltimore increased from 0.108 to 0.131 examinations per visit, which represents an increase of 21%.

There were also substantial changes in the average length of stay between 1993 and 1996. Nationally, there was a 14% decrease in the average length of stay (Table 3). The decrease at the Baltimore Veterans Affairs Medical Center of 22% was higher than the national average of 14%, while the decrease at the Philadelphia Veterans Affairs Medical Center of 8% was lower than the national average.

DISCUSSION

The utilization of radiologic services has a major effect on both quality of patient care and reimbursement. With all the financial implications at stake, it is surprising that so little research has been performed within the radiology community to evaluate trends and patterns of utilization and the effect of the introduction of new technology on the utilization of imaging services.

In one recently published study, Sunshine et al (11) evaluated radiologists' workload between 1991 and 1996. During the study, a small increase of approximately 5% was observed in the total number of examinations per full-time-equivalent radiologist, with an overall increase in total workload of approximately 13%, with allowance for increasing relative value units per procedure. These data confirm a relative increase in the use of high-technology modalities (CT, MR imaging), with a relative decline in the use of general radiologic examinations. These observations were also evident in our data but were accentuated with the implementation of PACS.

The financial implication of the rate of utilization of imaging services is intimately related to the type of payer contracts within the radiology group. In the traditional fee-for-service model, increased utilization of imaging services is highly desirable to radiologists, who are financially rewarded for increased utilization. Capitation or managed care contracts, on the other hand, provide a financial disincentive to radiologists to increase the volume of examinations, because this requires additional resources without additional compensation (12).

Imaging departments within the Department of Veterans Affairs, for the most part, utilize a capitation reimbursement mechanism. Medical centers within the Veterans Affairs system do not receive additional funding on the bases of increases in the volume of imaging examinations. This indirectly creates an incentive for salaried referring physicians to increase imaging utilization as a source of additional patient information without additional work on their part.

During the study between 1993 and 1996, despite the 8% decrease in the total number of examinations performed in the Veterans Affairs system nationally, there was a moderate increase of 18% in the volume of examinations in Philadelphia and a much larger increase of 48% in the volume in Baltimore. This increase in the volume of examinations in the academic medical centers in Philadelphia and Baltimore may in part be due to the introduction of new modalities, such as mammography and MR imaging, and to the trend toward increased use of cross-sectional examinations in teaching hospitals. The increase in Baltimore was, to a large extent, associated with a substantial increase in patient workload during the 1st few years after the relocation of the hospital from the suburbs to downtown Baltimore. This increase in the volume of examinations in Baltimore was observed for all modalities.

However, the increase in patient workload in Baltimore accounted for only a portion of the increased number of radiologic examinations. The inpatient utilization in Baltimore (examinations per patient day) increased by 82% in comparison to only 38% and 11% in Philadelphia and nationally, respectively. The outpatient utilization (number of examinations per outpatient visit) also increased substantially in Baltimore by 21%, despite no substantial change in Philadelphia and a 19% decrease nationally.

Before the introduction of the hospitalwide PACS at the Baltimore Veterans Affairs Medical Center, inpatient utilization was approximately equal to that at the Philadelphia Veterans Affairs Medical Center (0.265 vs 0.263 examinations per patient day). After the transition to filmless operation, the utilization at Baltimore (0.483 examinations per patient day) was more than double the national average and 33% more than that at Philadelphia (0.362 examinations per patient day). The pre-PACS outpatient utilization at Baltimore of 0.108 examinations per visit was intermediate between that at Philadelphia (0.087) and the Veterans Affairs national average of 0.148 examinations per visit. After the transition to PACS, the outpatient utilization average at Baltimore of 0.131 examinations per visit was approximately 50% more than that at Philadelphia and had exceeded the national outpatient utilization rate by 9%.

Although it is not possible to determine the causal relationship between the transition to filmless operation and the dramatic increase in the utilization of inpatient and outpatient imaging services from these data, it is tempting to speculate that the use of the PACS may have resulted in the increased utilization.

Radiologists have been taught that the best way to increase or maintain referrals for imaging examinations is to decrease report turnaround times, decrease patient waiting times, and provide easier access to images and reports. The transition to filmless operation at the Baltimore Veterans Affairs Medical Center has been documented (8–10) to improve all of these parameters substantially. For example, radiologists' reporting times have decreased from an average of more than 10 hours to approximately 30 minutes, while overall report turnaround time has decreased from 26 hours to approximately 2 hours.

The integration of the PACS into the health care enterprise information systems has facilitated the ordering and retrieval of studies within the patient's electronic medical record. Findings of surveys and direct observational studies performed at the Baltimore Veterans Affairs Medical Center (10,13) have consistently suggested a preference by clinicians for filmless operation because of the improved accessibility of imaging studies, which results in the improved utilization of clinician time. Findings of these studies have also demonstrated that clinicians have a greater tendency to review the images from the examinations that they have ordered in a filmless environment in comparison with a film-based environment. These operational improvements in imaging services and accessibility certainly may have played a major role in the tendency to order more radiologic examinations.

Another major factor in determining the utilization of imaging services is the tendency for hospitals, both within and outside the Veterans Affairs system, to decrease their average length of stay and to shift patient care to an outpatient setting. This shift may result in a smaller number of inpatient days per patient in which to perform imaging evaluation, which results in a larger number of examinations per patient day. This effect would be augmented by a tendency for patients who are admitted to have more severe and more complex disease processes, which would also increase the inpatient utilization of imaging examinations. This effect is supported by the national trend in the Veterans Affairs Medical System toward an 11% increase in inpatient examinations per patient day from 1993 to 1996.

The decreased length of stay may also increase the apparent outpatient utilization as patients who have a higher severity of disease are treated as outpatients. However, on a national level, the Veterans Affairs Medical System experienced a 19% decrease in the number of imaging examinations per visit. This decrease could be due to a number of factors, which include encouragement of radiologists and clinicians by the hospital administration to more stringently apply appropriateness criteria to decrease the number of ''unnecessary'' imaging examinations and general spending cuts that have taken place in the Veterans Affairs system nationally.

The average length of stay at the Baltimore Veterans Affairs Medical Center decreased more (22% decrease) than the national average (14% decrease) or the average at the Philadelphia Veterans Affairs Medical Center (8% decrease). However, it seems unlikely that these relatively small differences accounted for the dramatic differences in utilization during the study interval.

Other possibilities should be considered as contributing factors to the change in utilization in Baltimore. The move from the suburban location to downtown Baltimore may have changed the nature of the patient population served in addition to increasing the volume of examinations. However, when we compare utilization data between 1991 and 1993, no substantial changes were demonstrated in either inpatient or outpatient utilization ratios. One can conclude that the relocation of the hospital during fiscal year 1993 did not have a substantial effect on the utilization of imaging services. Furthermore, most of the 1993 data were collected after the move to the new facility (the new facility opened in January 1993), and no substantial change in the patient population or in the clinical services being offered was observed.

Another possibility is that the move to a new location adjacent to the University of Maryland School of Medicine and the University Medical Center may have played a substantial role in the increased utilization of services; but, again, the majority of the 1993 data were collected after the move to the new location. In addition, utilization at the Baltimore Veterans Affairs Medical Center in 1996 after the transition to PACS was substantially greater than that at the control medical center, the Philadelphia Veterans Affairs Medical Center, which is also university affiliated.

The 2-year gap between the implementation of filmless imaging at Baltimore Veterans Affairs Medical Center and the time of data collection was considered to allow for the S-curve transition period, which occurs when new technologies are adopted. This is the time required for staff to accommodate the new technology and effectively achieve a new equilibrium.

Undoubtedly, the rate of utilization of imaging services is a complex phenomenon that is multifactorial. It is likely associated with a number of factors, which include patient mix, geographic location, the radiologists themselves and their relationship to referring clinicians and patients, payer mix, accessibility and quality of imaging services, available imaging technology, the overall health care enterprise itself, medicolegal concerns, and the national health care environment. The temporal relationship between the introduction of filmless operation at the Baltimore Veterans Affairs Medical Center and the substantial increase in inpa-

tient and outpatient utilization does not prove but certainly raises the question of a causal relationship between the two, for the reasons cited above. This possible relationship has not been previously documented in the radiology literature and should be further investigated in other settings beyond our own academic Veterans Affairs medical environment.

Economically, the implications of increased utilization associated with filmless operation are profound. In our setting, at the Baltimore Veterans Affairs Medical Center, the use of the PACS has resulted in the ability to maintain previous levels of personnel and other resources, despite increases in the volume of almost 50% and in the total weighted work units by 69%. Although part of this increase in volume (and savings) has been due to an increased number of patients in the medical center, much of it has been due to the increased utilization of imaging services. Conversely, in a fee-for-service, outpatient environment, a substantial increase in utilization would augment rather than reduce the economic savings associated with a PACS.

It is critically important to ask the question of whether the change in imaging service utilization resulted in improved quality of patient care and ultimately whether increased or decreased utilization of services affected patient outcomes. For example, was the decrease of 19% in outpatient utilization in the Veterans Affairs Medical System nationally a trend toward a decrease in unnecessary services or one toward a decrease in the quality of patient care? Did the increase in inpatient utilization of inpatient care in Baltimore, after the transition to PACS, result in improved patient outcomes? In the absence of national or other published benchmarks, it is difficult to even determine how the Baltimore, Philadelphia, and National Veterans Affairs data compare with data from other medical facilities outside the Veterans Affairs system. Even if such data were more readily available, it is not clear whether such benchmarks would be useful, given the vast differences in the many parameters that determine utilization from one medical center or outpatient facility to another. Despite this difficulty, the authors believe that additional data should be collected to determine the appropriateness of imaging studies and whether PACS has had an effect on this parameter as well.

In conclusion, although cause and effect were not established, the transition to filmless operation at the Baltimore Veterans Affairs Medical Center was associated with a substantial increase in both inpatient and outpatient utilization of radiologic services. This increase was much greater than the change observed in a similar, film-based control medical center and the change for the Veterans Affairs Medical System nationwide. This suggests that the improvements in the imaging department associated with the PACS may result in greater utilization of imaging services.

The financial and clinical effects of an increase in utilization will depend on a number of factors specific to individual imaging departments. In an era in which utilization will be increasingly scrutinized, it is essential that additional data be collected to determine the effect of PACS in other practice environments. Radiologists must obtain information to better understand the ramifications of evolving technologies such as PACS on patient care, utilization of services, and financial reimbursements.

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