

Changes in Technologist Productivity with Implementation of an Enterprisewide PACS

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The purpose of this report is to determine what effect filmless operation has on technologist productivity when compared with traditional film-based operation. Retrospective data on technologist productivity was collected from the study institution before and after implementation of PACS using workload reports and payroll records. Departmentwide technologist productivity was defined as the number of examinations per full-time equivalent (exams/FTE) and correlated with local and nationwide standards operating in traditional film-based operations. During film-based operation, technologist productivity was comparable between the study institution and nationwide standards, allowing for the unique examination volumes and modality mix. After implementation of a large-scale PACS, technologist productivity was found to increase 34% above that of national standards and 48% that of the local control site. Implementation of an enterprisewide PACS offers the potential to significantly improve departmentwide technologist productivity when compared with traditional film-based operation.

KEY WORDS: picture archival and communications system, technologist productivity

OPTIMAL UTILIZATION of personnel resources within the imaging department has become critical in the current health care environment for a number of reasons. From an economic perspective, competition throughout the health care industry has intensified,¹ whereas reimbursements have declined with the federal government implementation of diagnosis-related groups² and the emergence of health maintenance organizations and preferred provider organizations.³ These economic pressures are intensified further by the increasing costs of newer imaging technologies as well as the relative shortage of qualified medical professionals. The Bureau of Labor Statistics estimates personnel demand within radiology will rise 29% between 1996 and 2006, with an additional

need for approximately 50,000 radiologic technologists.⁴ A recent national survey, conducted by U.S. Radiology Partners Inc, and reported in the bulletin of the American Hospital Association, stated 55% of all hospital-based radiology departments rank technologist staffing as their first or second strategic priority for 2001.⁵

These combined economic and workforce constraints place increased importance on technologist productivity. Whereas industry wide technologist productivity "norms" have been documented for film-based operation,⁶⁻¹⁰ little to date has been written documenting the effect of a large-scale picture archival and communication system (PACS) on technologist productivity.¹¹ PACS implementation has the potential to improve technologist productivity in a number of ways, including decreased examination times, reducing technologist fatigue, and eliminating filming and darkroom responsibilities.¹²

This study was performed to evaluate the relative effect of filmless operation on technologist productivity in an attempt to accurately determine personnel requirements and potential cost savings as more facilities undergo the

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Online publication 20 May 2002

doi:10.1007/s10278-002-0999-y

transition to filmless operation with PACS implementation.

MATERIALS AND METHODS

The study population consisted of all patients treated within the Baltimore Veterans Affairs Medical Center for the fiscal years 1993 and 1995 and the Philadelphia Veterans Affairs Medical Center for the fiscal years 1993 and 1996.

The Baltimore Veterans Affairs Medical Center implemented a large-scale PACS at the end of fiscal year 1993, resulting in the transition to nearly filmless operation. Consequently, data obtained before that time reflected film-based operation, whereas follow-up data in fiscal year 1995 reflected filmless operation. The Philadelphia Veterans Affairs Medical Center remained film based throughout the duration of the study (1993 through 1996). The Philadelphia Veterans Affairs Medical Center was chosen as a control site because of similarities with the Baltimore Veterans Affairs Medical Center in patient demographics, academic affiliation, geographic location, modality mix, and volume of studies.

Data for technologist productivity were collected from radiology workload reports and payroll records. Individual data from the Baltimore and Philadelphia Veterans Affairs Medical Centers were compared with national film-based standards, as published within the American Healthcare Radiology Administrators survey⁹ for the corresponding years of 1992 and 1995. Technologist productivity was defined as the number of annual examinations per full-time equivalent (exams/FTE), which was determined for each individual imaging modality. Composite measures of expected productivity, based on established American Healthcare Radiology Administrators (AHRA) norms, were compared with actual productivity measures as determined from radiology service fiscal year workload reports and payroll records.

All modalities other than mammography were included in the analysis. During the study period, the imaging equipment complement was comparable between the 2 sites, and none of the equipment studied was changed. Mammography was not included because of the overwhelmingly predominant male population served within the study institutions along with the fact that digital mammography was not available during the study period. Magnetic reso-

nance imaging (MRI) was not available at the Baltimore Veterans Affairs Medical Center in fiscal year 1993; therefore, no corresponding MRI data were included for that year.

RESULTS

Technologist productivity at the Baltimore Veterans Affairs Medical Center during the last year of film-based operation was comparable with nationally established AHRA norms (Table 1), with a net difference of less than 2%. Technologist productivity at the Philadelphia Veterans Affairs Medical Center (Table 2), was approximately 16% below these national norms.

After the transition to filmless operation with an enterprisewide PACS, dramatic gains in technologist productivity were observed at the Baltimore Veterans Affairs Medical Center in 1995. Imaging departmentwide technologist productivity measures increased by 25% compared with 1993 (film-based) levels and were observed to be 34% above expected national levels. These dramatic gains in technologist productivity occurred in the presence of a shift in the imaging department modality mix,¹³ away from general radiographic examinations, to the higher technology modalities (computed tomography [CT], MRI, ultrasonography) after PACS implementation. This observed shift constituted 10% and 19% decreases in the percentage of general radiographic examinations for inpatients and outpatients, respectively.

Although significant gains in technologist productivity were observed at the Baltimore Veterans Affairs Medical Center after PACS implementation, no changes in technologist productivity were observed at the film-based Philadelphia Veterans Affairs Medical Center

Table 1. Technologist Productivity at the Baltimore Veterans Affairs Medical Center (BVAMC): Comparison of Film-Based and Filmless Operations with AHRA Standards

Modality	1992 AHRA (Exams/FTE)	1993 BVAMC Expected FTEs	1995 AHRA (Exams/FTE)	1995 BVAMC Expected FTEs
General radiology	2,705	10.4	2,859	11.9
CT	1,396	3.1	1,556	3.9
Ultrasonography	1,528	1.2	1,667	2.0
Angiography	343	2.2	429	3.5
Nuclear Medicine	938	1.0	988	2.7
MRI	783	—	880	2.6

Note: Expected FTEs are based on national technologist productivity norms established by the AHRA, and are calculated relative to the facility's procedural volume.

Table 2. Technologist Productivity at Baltimore and Philadelphia VA Medical Centers: Comparison of Film-Based and Filmless Operations Relative to AHRA Standards

	Balt. 1993 (Film)	Phila. 1993 (Film)	Balt. 1995 (Filmless)	Phila. 1996 (Film)
Expected tech FTEs (AHRA)	17.9	16.9	26.6	21.8
Actual tech FTEs	17.6	20.1	19.9	26.0
Expected tech productivity (AHRA) Exams/FTE	2,042	2,129	1,946	2,102
Actual tech productivity Exams/FTE	2,077	1,790	2,602	1,762

over a similar time frame. Technologist productivity at the Philadelphia Veterans Affairs Medical Center was 16% below national norms in 1993 and 1996. The net difference in technologist productivity measures between Baltimore and Philadelphia Veterans Affairs Medical Centers in 1995/1996 was 48% versus a net difference of only 16% in 1993.

These observed changes in technologist productivity at the Baltimore Veterans Affairs Medical Center, after PACS implementation, are illustrated further by overall changes in staffing relative to examination volume. In fiscal year 1993, the total number of imaging examinations performed at the Baltimore Veterans Affairs Medical Center was 36,563. The annual number of imaging examinations increased to 54,201 in fiscal year 1996, resulting in a volume increase of 48%. During the same time interval, the actual number of technologist FTEs increased from 17.6 to 19.9, representing an FTE increase of only 13%. Comparable measures at the Philadelphia Veterans Affairs Medical Center in fiscal years 1993 and 1996, showed an examination volume increase of 18% versus a technologist FTE increase of 30%. These figures are opposite to one another and reflect the dramatic changes in technologist productivity when comparing film-based and filmless modes of operation.

DISCUSSION

Several studies to date^{14,15} have predicted large savings in personnel as a consequence of PACS implementation. These theoretical savings in personnel costs are largely driven by expected gains in technologist productivity, because most imaging departments provide reimbursement to radiologists on a fee-for-service basis, thereby excluding radiologists' salaries as

a part of the imaging department operational expense. Few publications to date have objectively quantified these changes in productivity after transition to filmless imaging.^{11,12} This documentation is of critical importance in the cost justification of PACS, because technologist working time represents the major portion of an imaging department's controllable costs.¹⁶

In a previous study by Reiner et al,¹¹ CT technologist working time was shown to be reduced by 45% with an enterprisewide PACS. This technologist productivity gain was caused by the elimination of a number of steps in film processing and handling. In film-based operation, CT technologists must individually photograph each set of desired window/level settings before image processing and printing. Once this is completed, the technologist must review and sort hard copy film images before submitting for radiologist interpretation. Several potential delays are encountered by technologists operating in a film-based environment including processor malfunction, film/chemical replenishment, and delays associated with retrieval of comparison studies and the patient's master film jacket. Lost or misplaced studies, as well as requests for additional copies place additional demands on technologist time and departmental resources.

In filmless operation, a number of operational efficiency gains are realized that have a positive effect on technologist productivity. In addition to the elimination of film processing and handling, decreases in lost examinations and retake rates have been well documented.¹⁷ At the Baltimore Veterans Affairs Medical Center, the lost examination rate has gone from 8% during film-based operation to 0.3% with filmless operation. At the same time, retake rates for general radiographic examinations have gone from 5% to 0.8% after transition

from conventional film-screen radiography to computed radiography. This is believed to be the result of the combined effects of the wider dynamic range of computed radiography coupled with the ability of radiologists to dynamically modify window/level settings at the computer workstation.

An additional, frequently ignored factor contributing to enhanced technologist productivity in a filmless imaging department is fatigue. Previous studies in the film-based radiology literature^{18,19} have reported as much as 20% additional time requirements when evaluating technologist labor costs attributed to "personal time" and fatigue. After transition from film-based to filmless operation, technologists report reductions in subjective levels of stress and fatigue.¹⁷ This is thought to be multifactorial in nature and caused by a number of factors including decreased interruptions by clinicians, improved patient throughput, enhanced scheduling (through the HIS/RIS interface), and electronic archive, which renders images and reports accessible throughout the medical enterprise. Newer modality worklist software has further enhanced technologist productivity and reduced fatigue by dramatically decreasing the frequency of data entry errors and transmission failures using PACS.²⁰

The concept of job-related stress and fatigue takes on greater importance in today's practice environment, with the relative shortage of qualified radiologic technologists currently available.^{4,5} This shortage is well illustrated by data obtained from the American Society of Radiologic Technologists, (McElveny C, unpublished data), which documents decreases in both new technologist graduates as well as training programs. In each successive year between 1994 and 2000, there has been a decrease in the number of first-time candidates taking certification examinations in radiography, from a high of 10,629 in 1994 to a low of 7,149 in 2000. Commensurate with this decrease in new radiographers is a reduction in the number of educational programs in radiography, from a high of 692 in 1994, to a low of 583 in 2000. This 33% decrease in the number of recent radiography graduates between 1994 and 2000 is further exacerbated by the increasing retirement rates among older radiographers.

The results in Tables 1 and 2 illustrate an interesting trend in technologist productivity during the study period. Based on established AHRA national norms,⁹ the expected technologist productivity (as measured by the annual number of examinations per FTE), at the Baltimore Veterans Affairs Medical Center actually decreased from 1993 to 1995 because of the dramatic changes in utilization of radiology services.¹³ In actuality, AHRA measures for technologist productivity increased for all modalities during the study period, from a low of 5.7% for general radiography, to a high of 25.1% for interventional/angiography. When taken in the context of these utilization changes, (from less labor intensive general radiographic examinations, to higher intensive, high-technology examinations like CT, ultrasonography, and MRI), the 34% increase in technologist productivity is even more impressive. Although technologist productivity measures were increasing at the filmless Baltimore Veterans Affairs Medical and nationally, no change in technologist productivity was observed at the film-based Philadelphia Veterans Affairs Medical Center, which remained film based in operation throughout the study period. The fact that technologist productivity at the Philadelphia Veterans Affairs Medical Center was 16% below that of national norms is believed to be multifactorial, and may in part be attributable to the patient population, academic affiliation, and unionized workforce.

The observed shift in utilization patterns of imaging services has additional ramifications on technologist productivity. As high-technology modalities such as CT and MRI take on greater significance within medical imaging, the effect on technologist productivity will be further magnified. Newer, more advanced applications including functional MRI, CT/MR angiography, and multislice CT will produce even greater time and educational demands on existing technologists. Whereas these advanced imaging techniques will revolutionize the practice of medicine, providers will not have sufficient resources to fully implement these services.

This imbalance between supply and demand among radiologic technologists will continue to widen as the US population continues to age, and medical imaging services continue to diffuse

outside of hospitals (into outpatient imaging centers and non-radiologist facilities). It is essential that technology is used to its maximum capability to address these shortages. Enterprisewide PACS offers the potential to increase technologist productivity, which, in turn, offers a number of theoretical advantages including decreasing operational costs, more timely delivery of imaging services, and improving overall quality of patient care.

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