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SCAR Radiologic Technologist Survey: Analysis of Technologist Workforce and Staffing

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One of the greatest dilemmas facing medical imaging departments today is the worsening personnel crisis in the radiologic technologist (RT) workforce. As the volume and complexity of medical imaging studies continues to increase, an unprecedented imbalance exists between RT supply and demand. A number of etiologic factors have been postulated to contribute to this RT shortage including decreasing morale, perceived inadequacies in compensation, decreasing number of training programs, and limitations in the career ladder. Previous studies have cited improved technologist productivity as imaging departments successfully transition from film-based to filmless operation. This study was undertaken to address the impact of digital technologies (information systems, PACS, digital radiography) on technologist productivity, in an attempt to determine whether these technologies can be used to positively affect the existing RT workforce imbalance. A total of 112 facilities participated in this nationwide study, with representation of imaging providers that paralleled the demographic profile of the marketplace as a whole. Survey results indicate the existing RT staffing shortage is greatest within academic and rural-based hospitals and is most severe in the area of general radiography, which accounts for 65-70% of imaging department volumes. For general radiography alone, respondents report an average shortage of 2 RT full-time equivalents (FTE's) per institution, when comparing the number of budgeted RT FTE's versus the actual number of RT FTE's. Preliminary results indicate that at this time, RT staffing shortages are not affected by the presence or absence of digital information technologies. Additional research is planned through a five-year longitudinal data collection, to better delineate the complex relationship that exists between implementation of digital technologies and RT staffing.

INTRODUCTION

DIAGNOSTIC IMAGING DEPARTMENTS have a dual mission that requires them to maintain the highest quality and consistency of patient care while maximizing efficiency and productivity. With the increasing financial pressures placed on medical imaging providers, these goals often become mutually exclusive. Decreased reimbursement rates, increasing technologist salaries in the face of a depleted workforce, and heightened competition among diagnostic imaging providers (both in and outside of the hospital), have resulted in greater pressure on radiology administrators to decrease personnel and operational expenses.[1]

One of the greatest impediments to optimizing imaging services is felt to be the worsening personnel crisis in the radiology technologist workforce. An unprecedented imbalance currently exists between the supply and demand of radiologic technologists (RT). The etiology of this imbalance is believed to be multifactorial[2] and includes the following variables:

1. The increasing average age of patients in the United States resulting in greater demand for diagnostic imaging
2. The increasing average age of RTs and associated attrition

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3. The increase in the overall number and complexity of medical imaging services, which has resulted in:
   a. greater expectations and stress on the limited workforce
   b. increased demand for subspecialized expertise among RTs.
4. The decreased number of people who are choosing the field of radiologic technology which, in itself, is multifactorial:
   a. limited RT career ladder
   b. decreasing number of training programs
   c. decreasing morale
   d. perceived inadequacies in compensation.

Statistics for the RT profession indicate progressive shortages, which will continue to worsen in the near future. According to a recently released survey by the American Hospital Association,[3] the current RT vacancy rate is 15.3%. Another survey from the American Healthcare Radiology Administrators[4] reports that only 42% of hospital-based radiology administrators believe that they have adequate technologist staffing, with an average of 2.8 full-time equivalent (FTE) technologist positions unfilled for general radiography (“plain film” studies) alone, per facility. Future employment projections by the US Bureau of Labor Statistics,[5] suggest that an additional 75,000 RTs will be needed in 2010, in addition to those that were in the workforce in the year 2000. This shortage of technologists represents a combination of new job growth along with continued attrition.

Several of the factors accounting for the RT shortage are impossible or difficult to rectify easily, such as the aging population and increasing demand for imaging services. However, some frequently overlooked measures that could potentially improve the supply versus demand imbalance in the RT workforce include improved productivity through workflow optimization, stress reduction, and implementation of advanced computer technologies within the imaging department.

This potential for improvement prompted our investigation of the existing RT workforce shortages and of its impact on various types of technologists. The purpose of this study was to determine the impact of information technology (IT) on technologist staffing. The pertinent information technologies considered were the hospital information system (HIS), radiology information system (RIS), HIS-RIS interface, and picture archival and communications system (PACS). By better understanding the complex relationship that exists between personnel requirements and digital technologies (information systems, PACS, and digital radiography), we can begin to strategize ways to address the workforce crisis through advancing the RT career ladder, enhancing productivity, and optimizing workflow.

METHODS

Survey Instrument for the SCAR Technologist Study

The survey instrument was designed by the principal investigators of the study, in consultation with the medical information division of IMV (Information Means Value, Des Plaines, IL), and can be accessed at the SCAR website.[6] The survey was designed to be longitudinal in nature, with a proposed 5-year study period. This will enable assessment of intra-and inter-site variability over time, specifically in assessing the impact of information systems and filmless technologies on radiology technologists’ productivity. It provides a demographic profile of the responding facilities including (1) information technology infrastructure, (2) breakdown of film-based versus filmless operation (by individual modality), (3) procedural volumes (by individual modality), (4) technologist staffing (by individual modality), (5) ancillary staffing (within the medical imaging department), and (6) operational issues (within the medical imaging department).

Data Source and Acquisition

The main source of survey candidates was the IMV Medical Information Division’s PACS and Master databases, which contain indices of all modalities surveyed by IMV across all sites nationally. This population consisted of a total of 2,472 hospital sites and 375 nonhospital sites. The IMV PACS census included 1,742 hospitals and 187 nonhospital sites, representing a 68% sample of the population of facilities.

During the course of conducting the PACS survey, IMV asked facilities to also participate in the Society for Computer Applications in Radiology (SCAR) Survey on Technologist Productivity. Of the initial group of IMV survey respondents, 1,236 contacts agreed to review the SCAR survey. The SCAR survey subsequently was faxed to potential survey respondents and followed with e-mails and telephone calls to verify receipt. Respondents were contacted at least 3 times after receipt of the survey. A total of

112 respondents participated in the comprehensive SCAR survey, representing a response rate of 6%.

Completed survey questionnaires were batch keypunched at biweekly intervals and reviewed for completeness of responses. Missing data elements were highlighted and followed up with telephone calls or e-mails to ensure all data were completed before analysis. Data were entered into an access database using a key and verify technique to address entry error.

Quality Control

Completed survey questionnaires were compared with existing data from previous IMV surveys to ensure consistency in the responses. The quality of data recorded was checked by a series of tallies and comparisons that ensured that only the appropriate codes were used and that stated values were within acceptable limits and consistent with other survey responses. Items flagged by the QC process were reviewed first manually in the database to determine whether they could be explained by related data and thus acceptable, or whether further investigation and clarification was required. For those items requiring further investigation, the responding site was contacted and asked for clarification or correction.

Additional quality control was implemented by the SCAR research committee investigators, who reviewed each individual survey by hand (in a blinded fashion), creating a list of questions for clarification by survey respondents. IMV staff telephoned each survey site a minimum of 3 times to review these final QC issues and obtain supplemental data as needed. The final database then was transferred to an independent statistician for analysis.

Analyses

Demographic and Technology Profiles

This report is a cross-sectional study based on the initial responses from the SCAR Survey on Technologist Productivity, which will serve as a baseline for longitudinal follow-up. Descriptive statistics were derived for demographic data (type of facility, area serviced, facility size) and information technology profile (with technology, without technology, implementation phase of technology). Facility and technology profiles were compared with the IMV PACS census data.

Technologist Staffing

The research questions for this investigation were targeted at determining if information technologies have an influence on technologist staffing in addition to demographic variables. The questions pertaining to staffing were constructed in 2 ways.

The instrument included quantitative and qualitative data on technologist staffing. The quantitative data consisted of the budgeted FTEs (full-time equivalents) and actual on-site FTEs by modality. The qualitative data consisted of a self-assessment of adequate versus inadequate staffing.

We evaluated the combined data on technologist staffing for the various modalities using subjective (perception based) and objective (FTE based) measures. For the subjective question, the proportion of facilities reporting adequate versus inadequate staffing was compared across all modalities using the χ^2. The mean and median budgeted and actual FTEs were calculated by modality and compared by inspection.

We assessed whether the actual FTEs were equal to or greater than the budgeted FTEs (defined as fully staffed) versus if actual FTEs were less than the budgeted FTEs (defined as understaffed). Facilities were dichotomized into fully staffed (budgeted equal to actual) versus understaffed (budgeted greater than actual). Two by two contingency tables were constructed to compare the proportion of fully staffed versus understaffed facilities based on the presence or absence of a RIS, HIS, HIS-RIS interface, and modality-specific PACS. This was done for each of the 7 modalities separately. The significance of these associations was determined using the Fisher's Exact test. The mean budgeted FTEs and mean actual FTEs were calculated for each modality and comparison within a modality was performed by the paired t-test.

The effect of demographics was evaluated for diagnostic radiography technologists. These analyses were based on 3 main categories (area serviced, number of hospital beds and type of facility) and were performed within each demographic category. The proportion of facilities reporting adequate versus inadequate staffing was compared using the χ^2 test. The differences in mean budgeted FTEs versus mean actual FTEs were assessed using a paired t test for each type of facility within each demographic subcategory. The medians were reported, and their differences were evaluated by inspection.

The effect of technology profile was evaluated for general radiography technologists. These analyses were based on 4 main information technologies (RIS, HIS, HIS/RIS interface, PACS). The proportion of facilities reporting adequate versus inadequate staffing was compared using the χ^2 test. The differences in mean budgeted FTEs versus mean actual FTEs were assessed using the t test for each subcategory. The medians were reported, and their differences were evaluated by inspection.

We evaluated whether a technologists training program influenced staffing levels. This was accomplished by comparing the proportion of facilities with modality-specific training programs to facilities without training programs. This was done separately for each modality and the significance of these associations was determined using the Fisher's Exact test.

RESULTS

Demographic and Technology Profiles

Of the 112 survey respondents participating in the study, 90% were classified as hospitals, with the remaining 10% predominantly representing high-volume outpatient imaging centers (Table 1). The majority (72%) of hospitals participating in the survey categorized themselves as community hospitals, whereas university hospitals represented 8% of respondents, pediatric hospitals 3%, and government and long-term care facilities collectively accounted for 7% of respondents. Table 2 lists the profile of areas serviced, with urban, metropolitan, and rural environs equally represented within the survey sample. Among hospital respondents, two thirds reported a bed size in excess of 200 (Table 3). Among hospital respondents, 69% reported the presence of technologist training programs.

Implementation of PACS and information systems technologies was greater for university and larger-sized community hospitals (Tables 4 and 5). Only 64% of smaller community hospitals (<100 bed size), reported the presence of HIS or RIS, and a fully integrated or interfaced HIS/RIS was utilized by only 41% of this group. University hospitals reported HIS and RIS implementation in 100% and 89% of facilities, respectively, with a fully integrated or interfaced HIS-RIS present in 89% of facilities. The use of information systems in outpatient facilities was similar to that of smaller community hospitals, with 73% of outpatient facilities implementing a RIS.

PACS implementation (by individual modality) followed a similar pattern among the sample group, with larger hospitals (>300 bed size) reporting PACS interfaced to the diagnostic and the cross-sectional imaging modalities computed tomography (CT), ultrasound scan (US) and magnetic resonance imaging (MRI) in 50% to 61% of the cases. Corresponding values for smaller sized hospitals include 18% to 27% for hospitals with less than 100 beds, 22% to 30% for hospitals with 100 to 220 beds, and 27% to 33% for hospitals with 200 to 300 beds. Of the different modalities examined, mammography remains almost exclusively film based for all survey groups, with only 3% of respondents reporting digital mammography interfaced to a PACS.

To evaluate the possibility of selection bias, we compared the SCAR sample with that of the IMV database, which was designed to be representative of the entire radiology imaging community. Demographic and technology profile comparisons of these 2 groups show similarities, as listed in Tables 6 and 7. Note that some of the demographic categories were modified in keeping with profiling differences between the two surveys. For the demographic profile comparison by bed size (Table 6), the distribution was nearly identical for the SCAR and IMV populations. When comparing the hospital type (Table 6), both groups contained 85% of community hospitals. The remaining 15% of respondents are divided differentially among government and university facilities, with 10% of IMV hospitals classified as governmental facilities and only 5% of the SCAR respondents falling into this category. This suggests that there was a substantially higher response rate by university facilities than by government ones to the more detailed SCAR survey, which suggests a sample bias with overrepresentation by academic facilities. A comparison of the technology implementation profile shows similarities between the SCAR subset and overall IMV samples (Table 7). The

Table 1. Type of Facility

Type	No. (%)
University hospital	9 (8)
Community hospital	81 (72)
Pediatric hospital	3 (3)
Government hospital	5 (4)
Outpatient imaging center	11 (13)
Other	3 (3)

Table 2. Area Serviced

Area	No. (%)
Urban	42 (34)
Metro	41 (33)
Rural	40 (33)

Table 3. Facility Size

No Beds	No. of Facilities (%)
<100	10 (11)
100-200	21 (22)
200-300	29 (31)
>300	34 (36)

Table 4A. Technology Profile: Implementation of Information Systems by Type of Facility

Information System Technology/Facility Type	With Technology	Without Technology	In Implementation Phase
HIS			
University hospital	100%	0	0
Community hospital	91%	6%	1%
RIS			
University hospital	89%	11%	0
Community hospital	77%	19%	4%
Outpatient imaging center	73%	18%	9%
HIS-RIS interface			
University hospital	89%	11%	0
Community hospital	73%	22%	3%

Table 4B. Technology Profile: Implementation of Information Systems by Hospital Size

Information System Technology/Facility Size	With Technology	Without Technology	Implementation Phase
HIS			
<100 bed	64%	36%	0
100 to 200 beds	91%	9%	0
200 to 300 beds	93%	3%	3%
>300 beds	100%		
RIS			
<100 beds	64%	32%	4%
100 to 200 beds	65%	30%	4%
200 to 300 beds	87%	10%	3%
>300 beds	89%	8%	3%
HIS-RIS interface			
<100 beds	41%	59%	0
100 to 200 beds	68%	32%	0
200 to 300 beds	85%	11%	4%
>300 beds	86%	9%	6%

percentage of the sites that used a RIS was similar for the 2 groups (78% of the IMV sample and 81% of the SCAR sample). However, there was a substantial difference in the percentage of sites that reported having a PACS (34% for participants in the SCAR survey but only 21% of the total number IMV sites). This discrepancy suggests that sites with PACS may have been more likely to participate in the survey.

Technologist Staffing

As outlined in the methods section, staffing was analyzed by modality, demographics, information technology profile, and the presence of a technologist training program. Modality assessment is summarized in Table 8. There was a significant difference ($P < .001$, χ^2) in adequacy of staffing based on modality (Table 8). General radiography had a disproportionate amount of perceived inadequate staffing compared with other modalities (60% *v* 17% to 29%). The quantitative measures (budgeted versus actual FTEs) also support this observation.

The median number of budgeted technologist FTEs for general radiographic examinations was 18.9, whereas the median number of actual technologist FTEs was 17.0, representing a disparity of almost 2 technologist FTEs. All other imaging modalities, however, report almost no difference between the actual and budgeted technologist FTEs, substantiating the perception by the facilities of adequate staffing in those areas.

There was no significant difference in fully staffed versus understaffed between facilities with a RIS and those without a RIS for all modalities except general radiography. The presence of a RIS was more common in the fully staffed facilities ($P = .03$). There was no

Table 5A. Technology Profile: Implementation of PACS and Modalities Interfaced by Facility Type

	Percentage of ExaminationsInterfaced With PACS by modality						
Facility type	Diagnostic	CT	Ultrasound	MRI	Nuclear Medicine	Mammogram	Interventional
University hospital	44%	55%	66%	44%	33%	11%	22%
Community hospital	31%	37%	32%	33%	23%	0	20%
Outpatient imaging center	18%	27%	18%	36%	9%	0	N/A

Table 5B. Technology Profile: Implementation of PACS and Modalities Interfaced by Facility Size

	Percentage of Examinations Interfaced With PACS by Modality						
Hospital Bed Amount	Diagnostic exams	CT exams	Ultrasound	MRI	Nuclear medicine	Mammogram	Interventional
<100	18%	23%	18%	27%	14%	0	9%
100 to 200	22%	26%	30%	22%	17%	0	13%
200 to 300	27%	33%	30%	30%	23%	0	17%
>300	53%	61%	56%	50%	36%	3%	25%

significant difference in fully staffed versus understaffed between facilities with a HIS and those without a HIS for all modalities. There was no significant difference in fully staffed versus understaffed between facilities with an HIS-RIS interface and those without an HIS-RIS interface for all modalities. There was no significant difference in fully staffed versus understaffed facilities with a PACS and those without a PACS for all modalities. There was no significant difference between budgeted and actual FTEs for all modalities.

Radiography demographic assessment is summarized in Table 9. There was no statistically significant difference (χ^2) in reporting adequate versus inadequate staffing between facilities based on the area serviced. The type of area serviced does not appear to have a significant impact on perceived staffing adequacy, although the discrepancy between budgeted and actual technologist FTEs is slightly higher for urban facilities than their metropolitan and rural counterparts. As the number of beds increased in a hospital-based setting, there was a greater perception of inadequate technologist staffing, with approximately two thirds of hospitals with greater than 200 beds reporting inadequate diagnostic technologist staffing. However, there was no statistically significant difference (χ^2) in reporting adequate versus inadequate staffing between facilities based on the number of beds. The median number of budgeted FTEs closely approximated the actual number of FTEs for larger bed-size hospitals, which is not the case for smaller bed-size hospitals. There was, for example, a net difference (actual versus budgeted) of 2.4 FTEs for hospitals with less than 100 beds. Both subjective and objective measures of diagnostic technologist staffing illustrate a difference depending on facility type. There was a statistically significant difference ($P < .01$, χ^2) in reporting adequate versus inadequate staffing between facility

Table 6. Facility Profiles of SCAR and IMV Samples

Facility	SCAR sample	IMV sample
Hospital bed size		
<100 beds	11%	13%
100 to 200 beds	22%	22%
>200 beds	67%	65%
Type of hospital		
Government	5%	10%
Community	85%	85%
University	9%	5%

Table 7. Technology Profiles of SCAR and IMV Samples

Technology	SCAR Sample	IMV Sample
RIS		
Yes	81%	78%
No	18%	21%
PACS		
Yes	34%	21%
No	66%	79%

Table 8. Combined Data on Technologist Staffing by Modality Objective and Subjective Measures

Modality	Reporting Adequate Staffing (%)	Reporting Inadequate Staffing (%)	Budgeted FTEs		Actual FTEs	
			Mean	Median	Mean	Median
Radiography	40%	60%	21.6	18.9	20.2	17.0
CT	73%	27%	6.1	4.5	5.9	4.0
Ultrasonography	71%	29%	4.7	4.2	4.5	4.0
MRI	83%	17%	4.7	3.0	4.5	3.0
Nuclear medicine	75%	25%	4.4	3.2	4.0	3.0
Mammography	81%	19%	3.9	3.0	3.8	3.0
Interventional/angiography	76%	24%	3.9	3.0	3.8	3.0

types. University hospitals are less adequately staffed compared with community hospitals and outpatient imaging centers. Outpatient imaging centers report the most adequate staffing (83%) and university hospitals report the least adequate staffing (12%) with community hospitals in the middle (42%). Analysis of the difference between median budgeted and actual technologist FTEs shows a similar pattern among the 3 different facility types, with the greatest disparity among university hospitals (2.4), followed by community hospitals (1.9), and finally, outpatient imaging centers (0.7). There was no significant difference in mean budgeted FTEs versus mean actual FTEs for any particular type of facility within each demographic subcategory.

Information technology profile assessment is summarized in Table 10. When correlating diagnostic technologist staffing and the different levels of implementation of digital information systems (Table 10), we found that no significant differences exist between those facilities that have adopted information system technologies or PACS compared with those that remain paper/film-based. There was no statistically significant difference in reporting adequate versus inadequate staffing between facilities based on the presence of an RIS. There was a significant difference ($P = .016, \chi^2$) in reporting adequate versus inadequate staffing depending on the presence of a HIS-RIS interface. Those facilities with a HIS-RIS interface were relatively understaffed compared with those without an interface, which was the opposite trend compared with other information technologies. There was no significant difference in the percentage of facilities reporting adequate versus inadequate staffing based on the presence of a PACS.

There was a discrepancy of approximately 2 FTEs between budgeted and actual technologist FTEs for general radiography. Interestingly,

Table 9. Demographic Profile of Diagnostic Radiography Technologist Staffing

Facility	Reporting Adequate Staffing (%)	Reporting Inadequate Staffing (%)	Budgeted FTEs		Actual FTEs	
			Mean	Median	Mean	Median
Area serviced						
Urban	44%	56%	22.5	22.0	21.0	19.0
Metropolitan	44%	56%	24.6	19.6	22.8	18.3
Rural	32%	68%	18.6	15.0	17.2	14.0
No. beds						
<100	60%	40%	11.8	12.4	10.8	10.0
100 to 200	45%	55%	17.3	13.0	16.5	12.0
200 to 300	31%	69%	18.5	16.9	17.4	17.0
>300	34%	66%	32.4	28.8	30.2	27.9
Type						
University hospital	12%	88%	31.9	30.8	29.9	28.4
Community hospital	42%	58%	22.1	18.9	20.7	17.0
Outpatient imaging center	83%	17%	5.9	3.7	5.6	3.0

Table 10. Technology Profile of Diagnostic Radiography Technologist Staffing

Technology	Reporting Adequate Staffing (%)	Reporting Inadequate Staffing (%)	Budgeted FTEs		Actual FTEs	
			Mean	Median	Mean	Median
RIS						
Yes	40%	60%	22.3	19.2	20.6	17.2
No	37%	63%	20.2	13.1	19.6	12.1
HIS-RIS interface						
Yes	38%	62%	22.5	19.2	21.0	17.3
No	55%	45%	16.3	13.1	14.9	11.6
PACS						
Yes	42%	58%	25.7	23.2	23.4	20.0
No	39%	61%	19.7	16.7	18.5	15.0

facilities with PACS that used digital radiography (either computed or direct radiography), reported a disparity of 3 technologist FTEs when comparing budgeted versus actual technologist FTEs.

Facilities with a technologist training program did not differ from those that did not with regard to the percentage that reported adequate versus inadequate staffing for each imaging modality.

DISCUSSION

This investigation was a cross-sectional study based on the initial responses from the Society of Computer Applications in Radiology Survey on Technologist Productivity and was designed to help identify significant factors associated with technologist staffing levels. We did not find a significant correlation between the implementation of medical imaging–related IT and the adequacy of imaging technologist staffing using subjective (perception-based) and objective (numerical-based) measures. We do not have sufficient data to determine from the survey results whether this reflects a lack of impact of HIS-RIS and PACS technology on technologist staffing levels or, alternatively, whether facilities that are understaffed such as university facilities are more likely to implement PACS. Other analyses showed that the type of area serviced and hospital bed size also were not significant factors in predicting technologist staffing adequacy.

However, the type of facility was significant with university hospitals being relatively more understaffed than community hospitals and outpatient imaging centers. These findings are similar to those reported in the recent 2001 AHRA Staff Utilization Survey.[4] The staffing dichotomy that exists between outpatient facilities and hospitals can be explained by the lifestyle differences afforded to technologists employed in an outpatient facility. The work schedule typically is limited to daytime hours with minimal if any weekend and holiday responsibilities. The patient population served is ambulatory, and after-hour call responsibility is nonexistent. The observed differences in technologist staffing between university and community hospitals also may be related partly to differences in patient populations, with university hospitals more prone to serving extremely ill, nonambulatory patients in addition to a larger proportion of the indigent population. At the same time, technologists employed in university hospitals often travel longer distances to work and find themselves in higher crime urban areas. All these factors may contribute to the observed differences in technologist staffing.

General radiography was the modality with the greatest problems with staffing compared with all other modalities, and this also correlates with the results of the 2001 AHRA Survey. A number of factors are believed to contribute to this disproportionate staffing shortage within general radiography, many of which may be related to the technologist profile. General radiography technologists tend to be younger and less experienced than their subspecialized technologist counterparts. As technologists work their way up the technologist career ladder, they typically migrate from the general radiography area to the "sexier" subspecialty modalities, such as MRI, CT, or ultrasonography. These subspecialty modalities offer better working hours, higher pay, and more prestige than general radiography. Whereas these modalities have relatively fixed, more predictable working schedules, general radiography workers work on a 24/7 "on-demand basis." This tends to create higher stress levels among technologists and precipitates the technologist migration to other areas, in and outside of the hospital-based imaging department.

We were intrigued by the seeming lack of advantages in staffing adequacy in those facilities that reported having a technologist training program on site. The cause and effect relationship between staffing adequacy and a training program is unclear because facilities with particularly poor staffing may be more likely to institute a training program. It also is likely that university programs, which often are understaffed for a number of reasons, are more likely to offer technologist training program, which may tend to improve their staffing situation without surpassing the staffing levels at community and outpatient facilities.

The SCAR survey was, by virtue of its length and level of detail, quite time consuming for individual facilities to complete. Of the 2,472 hospital and 375 nonhospital sites in the IMV "master universe," 1,742 hospital and 187 nonhospital sites participated in the general IMV PACS survey. Of those that participated in the general PACS survey, 1,236 facilities chose to review the much more comprehensive SCAR survey. Of the facilities that received the survey, 9% (112 facilities) chose to complete the SCAR survey. This represents 6% of the total number that participated in the IMV "master" PACS survey. It is, of course, difficult to determine the degree to which this 6% of facilities were otherwise representative of the general radiology community. The penetration of PACS was 56% higher (25% *v.* 16%) in the facilities that participated in the SCAR survey for those that had more than one year of experience with PACS than in the IMV general PACS survey. The percentage of "new" PACS sites (those with less than one year of experience) was 80% higher (9% *v.* 5%) in the SCAR survey population than in the general IMV PACS survey population. This higher percentage of established and new PACS sites in the SCAR survey suggests a greater likelihood of PACS sites to spend the time to collect data related to the impact of technology on technologist productivity than other facilities. There also was an underrepresentation of government hospitals (5% *v.* 10%) and overrepresentation of university hospitals with an equal number of community hospitals. It seems intuitive that this was because of the increased willingness of university facilities, in comparison with others, to collect and share their data and perhaps reflective of a reticence or lack of resources for governmental facilities to do the same. The effect of these selection biases on the ability to generalize the findings in this study to the general population of medical imaging facilities is difficult to determine with the obvious exception of a bias toward overestimating the penetration of PACS in the radiology community. If there was a selection bias toward greater participation by university sites and those with PACS it was not reflected in the degree of adoption of radiology information systems and the distribution of hospital bed amounts between the IMV and SCAR survey populations, which were similar.

When comparing this SCAR survey with other national published surveys from the AHRA,[4,7] several similarities in demographic and technology profiles can be observed, along with a few minor differences. For example, in both the AHRA and SCAR surveys, the majority of respondents were hospitals (85% AHRA, 90% SCAR), which, in turn, were primarily categorized as community based (86% AHRA, 86% SCAR). One substantive difference between the 2 survey samples however, was the distribution of hospitals based on bed size. Whereas a slight majority (51%) of AHRA respondents consisted of smaller hospitals with less than 200 beds, two thirds of SCAR survey hospitals reported bed amounts in excess of 200. This difference suggests that larger (often academic) facilities may be more interested in cooperating with academic and society surveys, especially when promised feedback on where their facility stands in relation to others in the study.

The data in our SCAR survey regarding technologist staffing are consistent with recently published data from a variety of professional and governmental organizations including the American Hospital Association (AHA), American Society of Radiologic Technologists (ASRT), American Healthcare Radiology Administrators (AHRA), and US Bureau of Labor Statistics (BLS).[3-5] Both the AHRA and SCAR surveys show that the imaging modality with the greatest degree of staffing inadequacy (in both objective and subjective measures) is diagnostic radiography. The surveys are nearly identical in their estimation of approximately 2 diagnostic technologist FTE positions unfilled as well as a perception of adequate staffing in only 40% of responding institutions. The perception of inadequate diagnostic technologist staffing has worsened when compared with the prior 1995 AHRA data,[9] which reported inadequate staffing for diagnostic technologists by only 26% of respondents. The disparities in technologist staffing by modality (Table 8) are similar to those previously cited in the 2001 AHRA staff utilization survey[7] and show that productivity and workflow optimization for radiography technologists are high priorities for medical imaging departments today.

This trend toward worsening diagnostic technologist staffing likely will continue into the near future and may become exacerbated as more imaging departments ask technologists to cross-train in multiple modalities, which typically depletes the ranks of general radiography technologists. At the same time, many general radiography technologists are actively pursuing subspecialty training in an attempt to move up the RT career ladder. This indirectly creates a negative perception among younger technologists who prefer to work outside of the diagnostic radiology realm, opting instead for careers in the "sexier," more technologically advanced, and financially rewarding modalities such as ultrasonography, MRI, and nuclear medicine.

It is ironic that technology implementation in itself may have a negative effect on technologist staffing in the short term by the creation of a new group of RT subspecialists, collectively referred to as PACS administrators. These individuals are recruited frequently from the ranks of the technologists and perform a variety of functions within and outside of the imaging department, including technology and implementation planning, systems monitoring, database maintenance, quality assurance/quality control, systems integration, budgetary analysis, equipment procurement, resource management, technology obsolescence protection, development of security policies and procedures oversight, and disaster recovery. As subspecialization within the technologist profession continues, new job titles likely will emerge. This may, in the long term, enhance future recruitment and retention efforts.

An example of another technologist career advancement being developed is the radiologist assistant. This is a technologist who serves under the direction of a radiologist and functions as a physician extender, performing several of the tasks previously designated to the radiologist. These functions could include preliminary interpretation of screening studies (mammography), and performance of some fluoroscopic and interventional procedures (eg, arthrography, venography). This concept currently is being used in England, where socialized medicine has brought forth a different perspective on allocation of medical resources. With increasing demands placed on an undersupplied radiologist pool, these "supertechnologists" have emerged to provide preliminary interpretations of emergency department radiographic examinations and perform certain procedures.[10,11]

A number of initiatives have been proposed by the ASRT to address the technologist staffing shortfall.[2] These include expansion of the RT career ladder to facilitate upward mobility among technologists, promotion of higher educational standards, establishment of state and federal regulatory professional standards, (such as the Consumer Assurance of Radiologic Excellence bill, which was introduced in the US House of Representatives in March 2001), and ongoing efforts at industrywide data collection. Our current SCAR-sponsored research project attempts to complement the efforts of the ASRT and AHRA in the identification of trends in the workplace, which may enhance technologist job satisfaction and productivity. Future data collection with an expanded survey sample will be required to further delineate the effect of PACS and information technology implementation on technologist staffing requirements. For general radiographic technologists in particular, it will be necessary to investigate the impact of developing technologies and their applications on technologist workflow and productivity. These developments include increased adoption of computed and direct radiography, workflow optimization software, advanced image processing algorithms, and a variety of newer diagnostic techniques such as tomosynthesis, and dual energy and temporal subtraction. Unfortunately, the number of respondents does not allow us to investigate differences between users of computed and direct radiography. This will be an area of future analysis, as more survey respondents implement PACS and these digital modalities.

CONCLUSION

Both existing and predicted future shortages in the RT workforce represent a crisis to the medical imaging profession. These staffing shortfalls were found to be more severe for general radiographic examinations, whereas cross-sectional imaging modalities seem to be less affected. Objective and subjective data suggest that RT staffing shortages are of greatest magnitude among larger, tertiary care university hospitals. The degree of staffing shortage was found in the study to be independent of digital information system and PACS adoption. A number of workforce and workplace enhancement programs have been proposed to address this supply versus demand imbalance.

Additional research is required to delineate the primary and secondary variables contributing to this RT staffing crisis so as to better develop interventions to counteract the recruitment and retention problems that are the fundamental source of inadequate staffing. This research should further explore the interaction between developing computer-based technologies and technologist productivity and workflow enhancements, as more institutions migrate toward filmless/paperless medical imaging. SCAR will continue to explore this vital area of investigation and look toward intersociety collaboration to achieve a better understanding of the challenges and possible solutions to this dilemma.

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REFERENCES

1. Reiner BI, Siegel EL: Technologist productivity in the performance of general radiographic examinations: Comparison of film-based versus filmless operations. AJR 179:33-37, 2002

2. www.asrt.org/toolkit/references/shortage_overview.pdf

3. www.aha.org/workforce/resources/content/fcgworkforcereport.pdf

4. Asante EO, Eberhart CS, Ising JJ, et al: Staff utilization survey American Healthcare Radiology Administrators, Sudbury, MA, 2001

5. www.bls.gov/oco/ocos105.htm

6. www.scarnet.org

7. Hanwell LL, Conway JM: AHRA survey on utilization of imaging staff: Measuring productivity, Sudbury, MA, 1996

8. Friedenberg RM: The role of the supertechnologist. Radiology 215:630-633, 2000

9. Robinson PJA, Culpan G, Wiggins M: Interpretation of selected accident and emergency radiographic examinations by radiographers: A review of 11,000 cases. Br J Radiol 72:546-551, 1999