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Daniel David Saketkhoo
Yale University

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Daniel David Saketkhoo
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Abstract

A HEALTHCARE SERVICES RESEARCH PROJECT: THE NATIONAL JOB MARKET FOR RADIOLOGISTS AND THEIR PROVISION OF EMERGENCY RADIOLOGY SERVICES.

Daniel D. Saketkhoo, Anne M. Covey, Jonathan H. Sunshine, and Howard P. Forman.

Department of Diagnostic Radiology, Yale University School of Medicine, New Haven, CT.

- Purpose is to present the most recent data on the nationwide diagnostic radiology job market using a help-wanted index and to investigate the provision of emergency radiology services.
- 1) All diagnostic radiology positions advertised in the *American Journal of Roentgenology* and *Radiology* between January 2000 and December 2002 were coded by practice type, geographic location, and subspecialty and were compared with previously published results from 1991 through 1999. 2) A telephone questionnaire asking about daytime image interpretation duties, night-time radiology coverage patterns, and radiologist staffing needs was administered to representatives of 97 private, community hospital emergency departments.
- From January 1999 through December 2002, 20,424 positions were advertised for diagnostic radiologists, representing a 287% increase as compared to the previous four-year period. The 12-month rolling average of job advertisements peaked in February 2002 (at 488 ads) and decreased rapidly to 432 in December 2002, a level not seen since August 2000. The proportion of academic advertisements has increased steadily during the past four years, from 34.0% in 1999 to 42.7% in 2002. A statistically significant relative increase in advertisements was noted in the Midwest. Statistically significant relative increases were also observed for the subspecialties of abdominal radiology, mammography, neuroradiology, pediatric radiology, chest radiology, and nuclear medicine; while statistically significant decreases were seen in general and vascular/interventional positions. Although relative demand for emergency radiologists has decreased, 23.7% of emergency departments surveyed reported shortages in emergency radiologist staffing. Radiologists perform daytime primary interpretation of plain films at 40.2% of these departments, CT scans at 93.8%, and sonograms at 93.1%. During the night-time, 8.2% of these departments possess no radiology coverge, 82.4% utilize teleradiology coverage in some form, and 9.3% employ in-house, rotating, "non-ER-dedicated" radiologists.
- Demand for radiologists has halted its multi-year ascent since Fall 2001. In addition, there is great variation in the provision of imaging interpretation throughout the nation, independent of emergency department size, location, and trauma center designation. Current policy should be directed toward training radiologists for areas of greatest need and developing standards for imaging interpretation across all subspecialties, including emergency radiology.

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Introduction

The Association for Health Services Research defines health services research as "a field of inquiry that examines the impact of the organization, financing, and management of health care services on the delivery, cost, access to, and outcomes of such services" [1]. As limited resources have recently placed financial constraints on the practice of medicine, there has been increasing demand for quantitative data concerning standards of care, distribution of subspecialist physicians, and cost-effectiveness of specific medical technologies, procedures, and treatments. As a result, execution of such health services research has increased rapidly over the past several years, especially by investigators who have an interest or stake in directing health care reform. Nevertheless, comparatively little health services research has been performed in the field of diagnostic radiology, and there remain questions regarding the state of the radiologist employment market and how a perceived shortage may or may not be affecting the delivery of medical care.

The ability to reliably predict the job market in diagnostic radiology is crucial for evaluating health services. Historically, this evaluation has been difficult, with different models and surveys producing conflicting assessments and, often, incorrect conclusions [2]. During the past several years, for instance, papers were published which alternatively predicted surpluses and shortages of diagnostic radiologists in the long-term future [2-4]. In 1982, the Graduate Medical Education National Advisory Committee projected a 34% *oversupply* diagnostic radiologists for the year 1990 [5]; while in 1990, a workforce expert projected an *undersupply* of 5000 radiologists at a time when only 21,900 were in practice [3].

Residency director and graduate surveys are currently the most common method employed for assessing the radiology job market. These surveys are well-suited for depicting past market trends, but are limited in that they present a unilateral, supply-side (job-seekers') outlook on the

market and provide retrospective, but not concurrent or predictive, information. Help-wanted indices (HWIs), such as the one utilized in this study, add great value because they present information from the demand-side (employers' perspective) of the job market and yield accurate data about current and future market trends [6-9]. The value and validity of these HWIs were originally described in the work of Nobel Prize-winning economist Robert M. Solow [6, 9], and later confirmed statistically by Gujarati through historical review of the national job market [8]. In fact, these models have been utilized over the past three decades in many different industries for both economic forecasting and predicting supply/demand trends in various labor markets [10].

Characterization of the radiology employment market holds great meaning beyond academic or personal curiosity and interests. Accurate, up-to-date, and detailed information about supply and demand imbalances yields tremendous value to government policy makers drafting legislation (concerning accreditation, standards of care, self-referral, etc.), radiology residency programs devising curricula, recent graduates seeking jobs, radiology groups interested in hiring, and even medical students planning careers [11]. For example, Anzilotti et. al. in 2001 demonstrated that changes in radiology hiring trends directly affect medical students' decisions to select radiology as a specialty [12]. In addition, such health services research has recently gained added importance due to mounting evidence suggesting a severe radiologist shortage – a shortage that casts doubts on radiologists' ability to provide timely, appropriate services and may threaten the future viability of radiology as an independent specialty.

One area of great concern involves the provision of emergency radiology services. The shortage of emergency radiologists often requires that non-ER trained radiologists and/or emergency physicians perform initial imaging interpretation. Currently, very has been published regarding how radiology and emergency departments have coped with this shortage or describing what type of coverage patterns they employ, particularly in the private, community setting.

Statement of Purpose and Hypothesis

The goal of this thesis is to quantify the national job market for diagnostic radiologists and to document current trends that may impact the delivery of radiology services and medical care. Specifically, this paper presents the most current help-wanted index data on the diagnostic radiology job market from January 2000 through December 2002 and compares it to the previously published results from the years 1991 through 1999 [11, 13]. The discussion focuses on how this data may influence policy planning and presents several solutions on how to correct supply/demand imbalances within the radiology employment market.

As an illustration, this thesis investigates the impact of the market structure on the organization of emergency radiology services at private, community hospitals. Through a phone survey and literature review, it aims to discover who performs daytime emergency department imaging interpretation and what types of night-time radiology coverage pattern predominate. In the conclusion, several options are discussed regarding how to restructure radiology services in order to optimize service.

Materials and Methods

*Part I: Help-Wanted Index

The methodology used to create the help-wanted index was similar to that used in the two previous studies help-wanted index studies performed by Forman et. al. [11] and Covey et. al. [13]. Please note that the collection and analysis of all data from 1991 through 1999 were performed by Drs. Forman, Covey, Sunshine, and Kamin [11, 13]. All advertisements in the classified sections of the *American Journal of Roentgenology* and *Radiology* were reviewed by the primary investigator during the 36-month period from January 2000 through December 2002. Each advertisement was divided into the number of unique job positions being offered, and each of these positions was coded according to three characteristics: (1) type of practice, (2) geographic region, and (3) subspecialty. In order to divide a single advertisement into multiple unique positions, there needed to be clear evidence that the advertisement was offering more than one position, and that each of these positions could be distinctly described. For example, an advertisement listing: "one opening for mammography, one opening for cross-sectional imaging, two openings for chest radiology, and one opening for nuclear medicine" was coded as five subspecialty positions; whereas, an advertisement stating: "opportunities exist in mammography, cross-sectional imaging, chest radiology, and nuclear medicine" was coded as one general position.

"Type of practice" was divided into academic versus private categories. Any private practice or partnership-track position was listed as private, whether or not there was university affiliation. All faculty listings, positions with academic ranking, and Veterans Administration medical center openings were considered to be academic. Administrative jobs were listed either as private or academic, depending on whether they were associated with private groups or with academic centers. Non-radiology and locum tenens positions were not counted, but part-time positions lasting for over one year were included. As before, no attempt was made to screen out repeated

ads. Neither nationwide advertisements, which offered multiple jobs across the country within the same listing, nor purely graphic advertisements were counted, all consistent with the previous methodology [11, 13].

For coding "geographic region", the United States was divided into six parts: the Northeast (NE), Midwest (MW), Southeast (SE), Northwest (NW), Southwest (SW), and California (Cal). The states included in each region are shown in Figure 1. Jobs advertised within Canada (Can) were also included in our data, but other foreign advertisements were not.

"Subspecialties" included were general radiology, mammography, abdominal and cross-sectional imaging, vascular and interventional radiology, neuroradiology, pediatric radiology, chest radiology, musculoskeletal radiology, emergency radiology, nuclear medicine, and "other." Nighthawk positions, which refer specifically to full- or part-time positions that consist only of dedicated night and weekend coverage, were coded as general, part-time, or "other", depending on how each was specifically advertised. As in our prior papers, "abdominal and cross-sectional" radiology encompassed CT, sonography, MR imaging, gastrointestinal imaging, and pelvic radiology. Subcategories of abdominal imaging included MR imaging and sonography, and were tabulated as a basis for future comparison in these potential growth areas. "Other" consisted mostly of administrative, chair, research, computer-interactive, and miscellaneous positions. A single position that was advertised as being split evenly between two subspecialty categories was entered as a half of each position, whereas single positions that involved three or more subspecialties were coded as one general position. From this point forward, the terms "positions" and "ads" will be used interchangeably to describe specific diagnostic radiology jobs that were coded and included in the study.

The collection, presentation, and statistical analysis of all the data were performed in a manner similar as in the previous two papers and are described in detail in the original article by Forman et. al. [11]. In interpreting the results, the new data from January 2000 to December 2002 were pooled with the data for 1999, from the most recent HWI paper [13]. Pooling of new and old data was performed merely for purposes of statistical comparison, allowing an equal 48-month sample period to be compared to the two previous 48-month periods (1991-1994 and 1995-1998). The actual current data, month by month, are presented in the tables and figures. In addition, in order to determine the locations of inflection points in the 12-month rolling average of ads per month, the percentages of change in the number of ads published from month to month were calculated and plotted. Inflection points were determined by noting positions at which this function crossed the x-axis. When comparing geographic location and subspecialty data across different time periods, statistical analysis was performed using a two-tailed comparison of proportions. P-values of less than 0.05 were considered to be statistically significant, and the p-values comparing the data from 1999-2002 versus 1995-1998 are reported in Tables 1 and 2.

Part II: Emergency Radiology Imaging Interpretation Services Investigation

For the emergency radiology practice pattern investigation, ninety-seven (97) private, community hospitals were administered a telephone questionnaire asking about their provision of daytime emergency department imaging interpretation services and their utilization of night-time emergency radiology coverage.

Hospital List

A random sample of 114 hospitals was selected from a list provided in the comprehensive *American Hospital Association Guide 2001-2002* database [14]. The randomization process tried to ensure that different geographic regions (northeast vs. south vs. west), population bases (rural vs. suburban vs. urban), and hospital sizes (small vs. medium vs. large) would each be

represented in a manner that reflected the community hospital distribution nationwide. The *AHA Guide* lists all United States medical centers in alphabetical order, separated by state, in 461 pages of text [14]. To achieve a random sample of around 100 hospitals, all medical centers listed third down from the top of every fourth page were selected to comprise the sample to be used for the telephone survey. Excluded from the study were hospitals listed in the *AHA Guide* as government, academic, and "specialty" and medical centers lacking emergency departments. "Specialty" institutions included children's, psychiatric, rehabilitation-only, nursing-only, orthopedic, and eye/ear/nose/throat hospitals. Whenever a chosen hospital fell into one of the excluded categories, a substitute hospital was selected by picking the hospital listed directly below it on the same page of the *AHA Guide* (i.e., the fourth, fifth, etc. hospital listed from the top of the given page).

Survey Administration

Ninety-seven (97) out of 114 community hospital emergency departments were administered the "Emergency Department Radiology Coverage" telephone survey displayed in Figure 2. Reasons for non-response are as follows: two hospitals no longer possessed working telephone numbers, three hospitals were academic centers, two hospitals did not have emergency departments, nine hospitals refused access to the emergency physician, and one emergency physician declined to answer the survey altogether. Deleting the three academic centers and the two hospitals with no emergency departments (because these five were "out of scope"), the response rate was 97 out of 109, or 89%.

The telephone survey was verbally administered to either an ER physician/director (74 cases) or ER nurse/administrator (23 cases), depending on availability. A maximum of five separate attempts was made to speak with an ER physician at each hospital emergency department. If department staff denied access to the attending emergency physician on all five occasions, then

no further effort was made to contact the emergency department and that hospital was deleted from the study. The 23 cases in which nurse managers were administered the survey occurred mainly in small hospitals, whose emergency departments were staffed by ER physicians on an on-call basis only. Here again, nurse managers were contacted only after every attempt was made to reach an attending ER physician. The same interviewer administered all surveys.

Data Collection

The interviewer categorized all participant responses into the corresponding answer choices listed in Figure 2. Although most responses fell clearly into one of the listed answer choices, ambiguous responses occasionally necessitated clarifying follow-up questions not described in Figure 2. For daytime coverage (questions 1-3), "radiologist initial-interpretation" was selected only when radiologists performed primary interpretation more than half of the time. Half-credit (0.5 out of 1) was given to radiologists if initial interpretation was split evenly between radiologists and emergency physicians. Meanwhile, for night-time services (question 6), radiology coverage sometimes varied from night to night (e.g., "five nights a week 'in-house radiologist' / two nights a week 'teleradiology-CTs only'"). In these cases, the assigned answer choice described the coverage arrangement occurring most often. In contrast to night-time services, no distinction was made between on-site or off-site (teleradiology) review during the day. Finally, for consistency, "ER-dedicated" radiologist was defined to all respondents as "either an ER fellowship-trained radiologist or a non-ER fellowship-trained radiologist who spends more than 50% of his/her time working exclusively in the emergency department."

Data Analysis

Data were stratified on the basis of patient volume and trauma center status. Of the 97 responding emergency departments: 26 were categorized as low-volume (less than 10,000 patient visits per year), 30 as medium-volume (10,000 to 25,000 visits per year), and 41 as high volume

(greater than 25,000 visits per year). Nineteen emergency departments were designated level-2 trauma centers, and 78 were non-trauma centers. No level-1 trauma centers were included in the study sample. For statistical comparison, the chi-squared test was used, with p-values of less than 0.05 considered to represent statistically significant differences.

Results

**Part I: Help-Wanted Index*

Overall Data

A total of 20,424 positions for diagnostic radiologists were advertised during the 48-month period from January 1999 through December 2002. Specifically, 3926 positions were advertised in the year 1999, 5576 in the year 2000, 5703 in the year 2001, and 5117 in the year 2002. This total averages to 426 positions per month for 1999-2002, compared to 176 positions per month for 1991-1994 (a 142% increase), and 110 positions per month for 1995-1998 (a 287% increase). The monthly peak of 599 ads was achieved during December 2001, while the monthly nadir of 37 ads occurred in July 1995 (Fig. 3). Although the absolute number of ads peaked during December 2001, the 12-month rolling average, which was calculated to minimize seasonal variation, peaked two months later (February 2002) at 488 ads. From February through December 2002, the rolling average declined with increasing momentum, to 432 advertisements by the end of the year, a level not seen since *August 2000* (Fig 3). In addition, the 5,117 ad total for 2002 represented a 10.4% decrease from the total for 2001.

When the percentage of change in the rolling average data from month-to-month is calculated (equivalent to the first derivative of the rolling average plot seen in Fig. 3), three clear inflection points can be identified (Fig. 4). In June 1992, the percentage of change switches from positive to negative (indicating a market top); in December 1995, the percentage of change switches back from negative to positive (indicating a market bottom); and recently, around November 2001, the percentage of change switches again from positive to negative (indicating another market top). These inflection points are also marked in Figure 3 for comparison.

Type of Practice

Thirty-eight percent (38%) of jobs advertised from January 1999 through December 2002 were for academic positions. This result represents a statistically significant increase ($p<.01$) from 36.1%, during the previous 48-month period from January 1995 through December 1998, but it is significantly down from 46.6%, during the period from January 1991 through December 1994. The widening of the gap between private practice and academic ads (absolute numbers) during the past several years, which was most pronounced during 2001 (Fig. 5), reversed itself during 2002. This phenomenon is best seen in Figure 6. During the course of 2002, the 12-month rolling average for private positions decreased from 301 to 247 ads, while the rolling average for academic positions remained steady at approximately 184 ads (Fig. 6). At the same time, the proportional (not absolute) gap between academic and private position has, in fact, been closing for the past four years, as academic positions have increased steadily from 34.0% in 1999 to 36.8% in 2000 to 37.2% in 2001 to 42.7% in 2002.

Geographic Location

Several geographic trends are noted when the data are compared with the results from the previous HWI studies [8, 15] (Table 1; Fig. 7). There has been a statistically significant increase in the relative number of jobs advertised in the Midwest, which accounted for 29.7% of total ads from January 1999 to December 2002 (up from 22.4% and 15.9% in the middle and earliest 48-month periods, respectively). The Midwest now accounts for the greatest percentage of positions advertised, having surpassed the Southeast (25.9%) and Northeast (23.0%) during the most recent 4-year period. Although the *absolute* numbers of ads for all six geographic regions increased substantially in the period 1999-2002 compared to the previous four-year periods, the *percentage* of ads in the Northeast (at 23.0%, compared to 25.8% and 27.4%) and Southwest (at 7.8%, compared to 9.8% and 12.4%) both exhibited statistically significant decreases. The percentage of ads also decreased in the Southeast and California, but these changes were not statistically

significant. Finally, the Northwest experienced an increase in its percentage of advertisements during the most recent 4-year period versus the previous one (6.7% versus 6.5%), but again this change is not statistically significant and still represents a decrease from the initial 4-year period (7.5%, in 1991-1995). When comparing the one-year data for 2002 to those for 2001, the absolute number of positions decreased in all geographic regions except California and the Northwest, where the numbers rose from 270 to 346 and 229 to 471, respectively (Fig. 8).

Subspecialty

Several subspecialties, including abdominal imaging, mammography, neuroradiology, pediatric radiology, nuclear medicine, and chest radiology all displayed statistically significant relative increases in demand for the period 1999-2002, as compared to the previous two four-year periods (Table 2; Fig. 9). Abdominal imaging accounted for 15.4% of ads (up from 10.2% and 13.7%), mammography 10.1% (up from 8.3% and 5.9%), neuroradiology 9.7% (up from 8.5% and 8.2%), pediatric radiology 4.6% (up from 2.7% and 4.4%), nuclear medicine 3.5% (up from 2.9% and 1.6%), and finally chest radiology 3.1% (up from 2.1% during the previous 48-month period). On the other hand, statistically significant proportional decreases in demand were observed in general radiology (down to 32.5%, from 39.7% and 43.4%) and vascular and interventional radiology (down to 13.4%, from 16.4% during the previous four-year period). There were no statistically significant changes in the proportions for musculoskeletal radiology or emergency radiology positions, but just as with all the other subspecialties, the absolute numbers of ads increased substantially for both (Table 2; Fig. 9). Finally, ads for MR imaging and sonography, which were included within the abdominal imaging category, accounted for 3.6% and 0.6% of total positions, respectively, listed from January 2000 through December 2002.

Part II: Emergency Radiology Imaging Interpretation Services Investigation

Characteristics of Emergency Departments

Tables 3 and 4 display the overall results from the "Emergency Department Radiology Coverage" survey. Thirty-nine of 97 emergency departments (40.2%) responded that radiologists initially interpret daytime emergency plain films, 90 of 96 (93.8%) reported that radiologists initially interpret daytime emergency CT scans, and 87.5 of 94 (93.1%) stated that radiologists initially interpret daytime emergency sonograms. One department reported that it does not possess a CT scanner, while three departments stated that they do not perform emergency sonograms under any circumstances. At all departments where radiologists do not make initial plain film, CT image, or sonogram interpretations, emergency physicians perform these functions. In all 58 of such cases, plain films are later over-read by radiologists after primary emergency physician interpretation. Average turnaround times range from just a few hours to slightly over one week for these radiologist over-reads. In only two out of 97 departments was it stated that "ER-dedicated radiologists" perform any emergency radiology work.

Overall night-time radiology coverage patterns are summarized in the first column of Table 4. Of note, 82.4% of emergency departments reported utilizing night-time teleradiology in one form or another, and none acknowledged employing an in-house, "ER-dedicated radiologist" for night-time work. Thirty-seven (37) of 97 (38.1%) emergency departments possess night-time capability to consult a radiologist about plain film questions; whereas 87 of 95 (91.6%) departments have their night-time CT scans read by radiologists in time for patient management decisions (Table 3). Two emergency departments, meanwhile, indicated that they do not have night-time access to a CT scanner; (this includes the one department that previously stated that it does not possess at CT scanner at all).

Although 23 emergency departments (23.7%) responded that, from their viewpoint, there exist staffing needs for radiologist of the ER, only one stated that it is currently recruiting for "ER-dedicated radiologists." The majority of departments noted that their hospitals are either looking for general radiologists or do not have sufficient funds to address their radiology needs. On the other hand, 74 (75.3%) departments implied that their emergency radiology coverage is adequate. The corresponding radiology groups/departments were not contacted for their opinions regarding these issues.

Comparison of Results Based upon Emergency Department Patient Volume

The survey results categorized by emergency department patient volume (low, medium, and high) are listed in Table 3. As emergency department patient-volumes increase from low to medium to high: the "radiologist daytime initial CT scan interpretation" proportion increases from 88.0% to 96.7% to 97.6%; "radiologist daytime initial sonogram interpretation" increases from 87.0% to 93.3% to 96.3%; "night-time immediate radiologist CT scan interpretation" increases from 79.2% to 93.3% to 97.6%; and "emergency department radiologist staffing needs" increases from 15.4% to 23.3% to 31.7%. The other parameters demonstrate no apparent relationship to emergency department size. Only the differences in "night-time immediate radiologist CT scan interpretation" were determined to be statistically significant.

Table 4 and Figures 10-12 display the reported night-time radiology coverage patterns for emergency departments stratified by patient-volumes. The vast majority of emergency departments in all three patient-volume categories employ teleradiology services for night-time coverage. Seventy-three percent (73%) of low-volume departments, 86.7% of medium volume departments, and 82.9% of high-volume departments utilize teleradiology in some arrangement, although the x-ray transmission capabilities vary slightly between the groups (Table 4). One

high-volume center (2.4%), meanwhile, employs teleradiology services for all plain films, whether there is a question or not.

As department patient-volumes increase from low to medium to high, the proportion of centers with "no night-time radiology coverage" decreases from 23.1% to 6.7% to 0%. Meanwhile, the most complete coverage, "in-house non-ER-dedicated radiologist," is found most often in high-volume centers (17.1%) and less often in medium volume (6.7%) and low-volume (3.8%) centers. The one low-volume department that was designated as having "in-house non-ER radiologist" coverage actually utilized a radiologist who takes call from his own house and comes into the hospital as needed to interpret all CT scans and difficult plain films.

Comparison of Results Based upon Trauma Center Designation

The survey results categorized by emergency department trauma center status are listed in Table 5. The proportions for all survey parameters are larger for the level 2 trauma centers than for the non-trauma centers, but the difference is statistically significant only for the question relating to "night-time plain film radiologist-consult capability." The results show that trauma centers are more likely than non-trauma centers to have a radiologist initially interpret daytime plain films (52.6% vs. 37.2%), daytime CT scans (100% vs. 92.2%), and daytime sonograms (100% vs. 91.3%). Trauma centers are also more likely to have an "ER-dedicated" radiologist perform emergency radiology work (5.3% vs. 1.3%), to have radiologists available to answer night-time plain film questions (57.9% vs. 33.3%), and to have radiologists immediately interpret CT scans (94.7% to 90.8%). In addition, ER physicians at trauma centers are more likely to report radiology staffing needs (31.6%) than they are at non-trauma centers (21.8%).

Table 6 and Figures 13 & 14 display the night-time radiology coverage patterns for trauma centers versus non-trauma centers. Of note, level 2 trauma centers tend to have more complete

night-time radiology coverage than non-trauma centers. Thirty two percent (32%) of trauma centers reported employing "in-house radiologists" for night-time coverage versus only 3.8% for non-trauma centers, while 10.3% of non-trauma centers acknowledged "no night-time radiology coverage" versus 0% for trauma centers.

Discussion

**Part I: Help-Wanted Index*

Current Market Situation

There currently exists a consensus in the medical community of a severe shortage of diagnostic radiologists. Anecdotally, both private groups and academic departments have reported extreme difficulty in recruiting radiologists, often having to offer extraordinary salaries, generous vacation time, and less than two years to partnership. Median salaries for entry-level radiologists, for instance, increased by over 20% last year according to one published survey [15]. Multiple studies have tried to describe and understand this radiologist shortage. In 1998, the American College of Radiology's (ACR) survey of hiring reported a nationwide undersupply of 600 radiologists [16], while demand projections performed by Bhargavan et al. in 2001 estimated the shortage at 5% of approximately 26,000 currently practicing clinicians [17].

Several theories have been postulated as to the causes of this radiologist shortage. Specifically mentioned are the growth and aging of the population that have led to increased demand for imaging (and medical care in general), the demise of managed care that has shifted power from primary care physicians to subspecialists, the increased demand for 24-hour radiology coverage that has reduced radiologist availability, and the effects residency position cutbacks during the mid-1990's that are just now beginning to be felt as fewer trainees graduate. During his talk at the RSNA 2002 meeting, Sunshine pointed out that although the number of radiologists grows by 1.5% per year, the number of procedures grows by 4.5% annually and relative value units by 6.0% annually [18]. In addition, patients are individually demanding more intensive imaging, as the complexity of procedures per age-standardized American is increasing by at least 1.75% per year [18]. At current levels of growth, Bhagarvan et al. project a deficit of 10,000 to15,000 radiologists by 2015 (almost half the number of radiologists nationwide today) [17, 18].

Regardless of the cause, there is little question that the radiologist shortage intensified dramatically during the late 1990's. Since 1996, surveys of residency program directors have consistently demonstrated decreasing levels of unemployment among graduates, greater ease in finding job positions, and increasing employment in jobs that match graduate training and goals [19-21]. Surveys of these newly trained radiologists, meanwhile, have indicated increases in the number of job offers and improved initial job satisfaction [13, 21]. Finally, the ACR's Professional Bureau, the largest placement service in diagnostic radiology, reported an increase in the ratio of job listings per job seeker from 1.3 in 1998 to 3.8 in 2000 [22]. Conflicting opinions now exist, though, as to whether the employment market has begun to reverse itself over the past two years, and also whether the employment prospects across different diagnostic radiology subspecialties vary or remain approximately the same [13, 19, 23]

Study Findings

While confirming the existence of a severe a radiologist shortage, our study has found that the shortage in the overall job market for diagnostic radiologists, which began in December 1995 (Fig. 3, 4), may have begun to reverse itself. The rate of job increase nationwide slowed dramatically during early 2000, and ads have actually decreased since November 2001 (Fig. 3, 4). In fact, the 12-month rolling average for ads in December 2002 dipped to a level (432 ads) not seen since August 2000. Nevertheless, it is too early to state with certainty whether these findings represent a substantive, more permanent reversal in the market or just a temporary blip that would indicate adjustment or stabilization.

At this point, the findings do not suggest that the market situation is reverting back to the tough times of the mid-1990's. Instead, it appears as though the current strong market is continuing unabated, but not becoming even more overheated. Such a stabilization of the shortage is in fact desirable, as being near equilibrium should prevent a major, detrimental undersupply of

radiologists from developing. Currently, more than 50% of radiologists already report that they are overworked [24]; if the shortage were to continue to grow, as it had in recent years, the situation would become even more serious.

Because the number of entrants into the field has been fixed at a constant level (constrained by the number of residency graduates each year) and because imaging volume (demand) has increased substantially [25], this slowdown, if real, can only be accounted for by increases in productivity and/or increases in non-traditional physician supply. Indeed, technological innovations, PACS implementation, computer-aided diagnosis, and teleradiology operations may be improving productivity. Radiologists also report that they are working longer hours [24] Enhancing the productivity argument is a recent *Radiology Business Management Association Bulletin* report that demonstrated that academic radiologist productivity—as measured in relative-value units (RVUs) per full-time equivalent radiologist—grew by 11.5% in 2001 as compared to 2000 and by 34.6% since 1997 [26].

In addition, there have been numerous informal reports of recruitment of retired and part-time radiologists to assist those overburdened by increased workload requirements. One cannot rule out, though, that radiology practices may have given up on journal advertising as the shortage has worsened, as journal advertising could represent a declining method of finding radiologists. Thus, it is possible that changing recruitment practices, such as electronic advertising and use of "headhunter" services, may have also helped to account for the lower overall ad totals during the past few months without reflecting true changes in market demand.

Despite these influences, there exist almost three times as many positions advertised nationwide as there were four years ago. While market pressures in private practice have eased, the shortage in academics continues unabated. Large numbers of radiologists are being drawn from academic

centers to private practice, as evidenced in Figures 5 and 6. Although only 20% of radiologists work in academic settings [27], academic positions comprised 42.7% of ads coded in 2002, up dramatically from 34.0% in 1999. This trend correlates well with a recent report that nearly 600 radiology department chairmanships, directorships, and section leader positions are currently vacant in the United States [28]. Another study has placed the number of overall faculty openings at an average of five per institution nationwide [29].

In addition to academic centers, rural areas have been hardest hit by the radiologist shortage. In the Midwest, for example, the absolute number of advertisements per year has more than quadrupled and the relative proportion has almost doubled since 1995. The proportion of ads in the more rural Midwest increased from 15.9% to 29.7% over the past 12 years, while the proportion of positions in all other areas of the country declined (Table 1). In fact, it is not uncommon for many private and academic hospitals in the Midwest to be advertising to re-staff almost entire departments.

Changes in subspecialty demand have been less dramatic. The relative demand for general radiologists has continued to decrease, while the most pronounced relative increases in subspecialty demand have been witnessed in mammography, pediatric radiology, and in abdominal imaging, driven by growth for MR imagers. These increases in demand were most pronounced in California and the Northeast, where a majority of all advertisements in these regions for 2000-2001 were for these two subspecialties. Though increasing numbers of advertisements may suggest that radiologist shortages exist within these fields, it may alternatively indicate overall growth of those fields, with more positions being advertised to larger pools of fellowship-trained radiologists. Meanwhile, slight decreases seen in emergency radiology demand may be due to staffing of emergency departments with radiologists from other subspecialties, especially abdominal imagers.

Help-Wanted Index Characteristics and Limitations

We believe that our help-wanted index analysis usefully portrays the current radiologist employment situation. As mentioned earlier, an HWI has been used for the general economy for decades, and its development is based on the original work of Nobel Prize-winning economist Robert Solow [6-9]. Furthermore, the HWI's value and validity for the radiology job market in particular have been outlined in the previous HWI papers [9, 11]. Substantial caution, however, should be exhibited when using HWI data to analyze the employment market and predict long-term trends. Several characteristics of the HWI must be weighed carefully.

First, a help-wanted index is an indirect (not a direct) measure of demand pressure in labor markets. It does not quantify the actual number of vacant positions or unemployed job-seekers, but rather tracks the number of job advertisements. These advertisements are sometimes repeated and sometimes outdated, and whether to advertise is often left to the discretion of the employer. Thus, indirect indicators, like the HWI, have no natural scaling. Absolute numbers mean little; only general trends can be described [6].

Second, help-wanted index forecasting is not immune from potential technology and policy changes that have caused radiology job-market prediction to be so difficult historically. Novel imaging techniques (such as functional MR imaging, molecular, and genetic imaging) and new interventional techniques may significantly increase demand for radiologists in the next several years in ways that cannot be calculated, just as new technologies have in the past. For example, in 1990, over 60% of radiology work was derived from techniques like CT, MR imaging, and sonography that were not available only 25 years before [4]. On the other hand, productivity gains due to PACS, computer-aided diagnosis, and teleradiology may help to offset some of the predicted increased volume. In addition, health care reform and changes in medical delivery

systems can potentially impact volume of imaging demand, thus altering dramatically future market conditions.

Third, the number of advertisements is related to the size of a given field, as well as the demand for employees. HWI data must be corrected for the overall growth of a specific field, not performed in this study. For example, if nothing but the scale of the labor market ever changed (independent of unemployment rate), one would expect the HWI to rise with the number of job seekers and number of establishments advertising [6]. This should not be an issue for the radiology market as a whole, since the number of entrants has been fixed by the number of annual residency positions (900) for the past several years. It may have an impact, though, on the subspecialty data, as the proportional increases in ads noted for fields such as abdominal imaging, mammography, and nuclear medicine may be due in part to the overall growth of these fields in addition to shortages in these subspecialty-trained radiologists.

Fourth, the HWI tends to magnify market trends. As unemployment decreases, the number of ads required to fill a single vacancy should increase at an accelerating pace. Conversely, as the unemployment rate rise, the HWI should fall off rapidly as active job hunting makes direct advertising largely unnecessary. This curvilinear relationship between the HWI and unemployment is especially pronounced at very low levels of unemployment, (such as that seen in the radiology job market today), and has been documented by Burch et al. through historical review of the manufacturing sector of the economy [7]. As a result, trends noted in this paper may exaggerate the true details of the market. Large proportional increases in certain geographic areas (i.e., the Midwest) and specific subspecialties (pediatrics, mammography) may be partially explained by this effect. On the other hand, this sensitivity allows our HWI study to highlight subtle trends that may not otherwise be identified by alternative forms of analysis (i.e., surveys and modeling).

Fifth, the HWI tends to lag the true market by several months. Cohen et al. documented that there is more help-wanted advertising late in an upswing (rather than early) and less advertising late in a downswing [6]. This lag is mainly due to the fact that formal advertising is a last-resort method of recruitment. During upswings, such advertising costs money and hurts prestige, and so is usually avoided until absolutely necessary. During downswings, meanwhile, there is often belated recognition of labor market conditions and ads tend to remain in print for extended periods before being pulled [6]. As a result, the labor market for diagnostic radiologists probably peaked sometime before the November 2001 date that was reported in this study. Nevertheless, HWIs provide a more current picture of the labor market than do surveys, which sometimes take months to collect and analyze.

Finally, our HWI may not be completely comprehensive. We looked only at journal advertising, and alternative forms of advertising do indeed exist (internet databases, professional bureaus, headhunters, word-of-mouth, etc). This characteristic should have little impact on our data though, as there have been no changes in advertising policy (fees, format, availability) that could account for any shift in overall advertising over the past several years. Although some private practices may have given up somewhat on some journal advertising during the past several years (due to diminishing returns as the market grew tighter), anecdotal reports suggest this to be an exception and not the rule. Also, academic institutions are required by law to advertise in print all positions for a specific number of months in order to satisfy equal opportunity regulations, and so the database for academic positions should be up-to-date and all-inclusive.

Potential Consequences

A continuation of the radiologist shortage described in this study portends two very serious consequences. First, radiologists stand to lose "turf" to other medical specialties should they be

unable provide optimal services. One example of what can happen due to a significant shortage in supply of trained radiologists is seen today in vascular and interventional radiology. With improved techniques for minimally invasive diagnostic and therapeutic procedures, the job market for vascular and interventional radiology has increased dramatically during the past decade. In fact, from the nadir of 74 ads in 1994, the number of advertised positions has increased over ten-fold to 760 ads in 2002. At the same time, the number of interventional radiology fellowship positions has remained relatively stable at 200 nationwide, and number of fellows has dipped to below 100 (as residents forego additional training for lucrative private practice employment).

While this may be good news for residents and fellows searching for jobs, other medical specialists have stepped in to fill the void by performing interventional procedures themselves. In comparison to the 100 interventional radiology fellows, 750 invasive cardiologists graduate and enter the work force each year. Today, many cardiology practices are repositioning themselves as cardiovascular ones, interpreting cardiac and peripheral MR angiograms, and performing carotid, renal, and iliac artery stenting procedures [30]. Almost 20% of invasive cardiology training programs teach peripheral vascular disease management. Recognizing this trend, the ACR recently approved a resolution to recognize vascular and interventional radiology as a separate component of Radiology. The Society of Cardiovascular and Interventional Radiology has supported this resolution, and it hopes to increase the number of practicing full-time equivalents in vascular and interventional radiology by 40% before 2006 [20].

Interventional radiologists are by no means the only group affected by the current shortage. The number of radiology residency positions nationwide fell during the mid and late 1990's due to anticipated funding restrictions following the Balanced Budget Act of 1997, decreasing entrants into all subspecialties. Emergency department physicians, orthopedic surgeons, obstetricians,

nephrologists, and cardiologists (to name but a few) have responded to the shortage of appropriately-trained radiologists, and now interpret images or perform image-guided procedures themselves to expedite patient care. Many radiology groups have countered by increasing staffing in emergency departments, either with 24-hour in-house coverage or from home through teleradiology, in order to limit their loss of market share. If the radiologist shortage continues, then these "turf" losses will probably intensify, as better-positioned specialties step in.

Second, the loss of academic radiologists to private practice holds serious repercussions for residency training programs. With fewer bodies to deal with increasing clinical workload, faculty members now have less time to dedicate to teaching and research. The American Board of Radiology (ABR) requires a minimum 1:1 ratio of faculty to residents for each training program and at least one full-time faculty member in each subspecialty division. Thus, continued loss of faculty would not only compromise the quality of resident training, but it would also cast doubt on the viability of programs in their entirety. Decreased research, meanwhile, results in less innovation and advancement in the field, and a yielding of the most exciting and lucrative procedures to other specialties, further compounding the "turf loss" issue.

Potential Solutions

It is elear that it is of paramount importance that our national organizations respond to this crisis and work to increase the number and efficiency of radiologists in tomorrow's workforce. An all-radiology leadership task force convened by the ACR in 2001 studied possible changes and made recommendations. The ACR has put many of these into effect. It is hoped that this paper has presented a useful overview of the current employment market conditions and provided sufficient details to allow for continued evolution of an effective course of action. Specifically, from this paper, it is evident that the most critical shortages currently exist in the fields of mammography,

pediatric, and abdominal imaging, and so potential solutions should be crafted with their needs in mind.

One short-term solution would be to increase the number of part-time, retired, and internationally-trained radiologists in the workforce until a long-term solution can be implemented. Sunshine et al. has documented that currently 10% of post-training radiologists are working part-time in radiology and 17% are in retirement and not working at all [24]. Though it may be difficult to succeed, efforts to tap into this labor pool could only help. Also, general radiologists (whose demand is in decline) could be encouraged, through possible government or private radiology-group subsidies, to undergo additional training in mammography, pediatric, or abdominal imaging, allowing them to perform more of the work.

A more permanent solution would be to increase the number of radiologists in the training pipeline. After reductions during the 1990's, many residency programs are now just beginning to increase their number of ACGME-approved slots. Today, there are 3,769 positions at 192 radiology programs, and 172 residency positions were added during the year 2002 [32]. Unfortunately, funding today remains a major issue, with over 70% of programs reporting financial support to be the major limitation [32]. Aside from finances, there exist a few other obstacles to further increasing the number of residency positions. First, the Residency Review Committee (RRC) requires at 1:1 ratio of faculty to resident, (the current ratio is 37.2 / 28). Second, the RRC mandates that each resident interpret more than 7,000 exams per year, (the current average is 12,000). Third, state-mandated primary care requirements at some hospitals restrict the quota of radiology residents at 13% of programs [32]. Nevertheless, it has been estimated that, considering all these factors, more than 300 additional trainees can be accommodated nationwide if funding can be secured [32].

Although federal legislative attempts to increase funding for trainees have recently failed, other sources may still be procured. The Centers for Medicare and Medicaid Services does not restrict the number of trainees, only the funding. As an alternative, private radiology groups could take it upon themselves to fund residency slots in return for guarantees that residents would join their practices upon graduation, much like corporations do for Masters of Business Administration students.

The ABR has already done its part to increase the number of radiologists in the training pipeline. This year, the ABR relaxed the U.S. training requirement for foreign radiology graduates, allowing them to become U.S. board certified without repeating residency training if they perform a fellowship at an American program, followed by 3-4 years of academic practice [32]. This rule change should entice more foreign radiologists to perform fellowships in the United States and then function as junior academic attendings, in turn helping to alleviate the academic radiologist crisis.

A third solution to the radiologist shortage lies not in increasing the size of the workforce, but in further improving radiologist productivity. While it would be difficult and expensive to train 5% to 10% more radiology residents, it may be easier to obtain 5% to 10% greater efficiency from radiologists currently in practice without increasing workload appreciably. Radiologists currently spend a great amount of time on non-cognitive issues, often performing clerical functions that are more efficiently carried out by others. In many cases, radiology practices have not fully captured the efficiencies of new technologies; instead incorporating them into old processes, rather than re-thinking the entire way of providing services in the setting of technological innovation. With modest capital expenditures and a willingness to accept change, many radiology practices (who have not already done so) could begin to implement Internet-based PACS, teleradiology, radiology information systems, and voice recognition systems. Although there is no literature

that currently substantiates the benefits of these technologies, scattered reports indicate promise. Practice settings must be enabled to allow this potential benefit. For example, merely adding voice recognition systems, when dictation was previously the rule, does not improve efficiency. Only with a shift in the previous resources to better use this technology, can it be thought of as helpful.

These technologies could not only expedite information processing, but could also increase coordination between different radiology centers. Increasing flexibility could make it easier on radiology groups to outsource work to others in times of peak demand, and so distribute work more effectively through pooling of resources. Specifically for mammography, development of digital mammography and computer-aided diagnosis systems could eliminate the need for a second reading, thus decreasing the workload substantially, although it is recognized that these systems have not been perfected yet. Meanwhile, in the clinic setting, increasing reliance on allied health care professionals, such as nurse practitioners, clinical nurse specialists, and physician assistants, in patient-related tasks would free up radiologists to perform more technically complex and demanding duties.

Finally, redistributing radiology trainees could serve as another means of the alleviating the shortage. Residency program directors and advisors should understand the market situation and be able to guide trainees into areas of increasing need, including mammography, pediatric, and abdominal imaging. As Anzilloti et al. [12] showed, physicians respond to market demands: shortages lead to increased salaries, and increased salaries lead to increased entry. Fellowship cycles (1-2 years) are much shorter than residency cycles (4-5 years), and so mismatches across different radiology subspecialties can be addressed in a more efficient manner than the shortage within radiology as a whole.

It must be recognized, though, that the primary goal of increasing the number of radiologists to meet demand is to provide optimal patient care. This includes several factors: including having enough radiologists to perform and interpret imaging studies, providing time and resources to develop new imaging and interventional techniques, as well as minimizing diversion of studies to other physicians not trained to perform or interpret imaging studies. Further, we must have sufficient numbers of educators to train the next generation. Therefore, it is not only in our own interest, but also in our patients' best interests, for us to understand the job market to be in a position to protect our "turf." A detailed illustration of this is discussed in the next section, pertaining to emergency department imaging interpretation services.

**Part II: Emergency Radiology Imaging Interpretation Services Investigation*

Emergency Radiology Background

The radiologist shortage has impacted all subspecialties within radiology, including the practice of emergency radiology. This need for emergency radiologists has taken on added importance because imaging interpretation in the emergency setting is becoming critical to the care of most patients. While academic departments typically have a radiologist (either in-training or at the attending level) at all hours, this is infeasible in smaller community hospitals, particularly those in rural areas. The growing reliance on imaging findings for patient work-up and treatment -- combined with previously described nationwide radiologist shortage, an explosion of imaging techniques, and questions about self-referral-- has caused many emergency and radiology departments to rethink the provision and interpretation of their radiology images. Hospitals and payers, who maintain large financial stakes in these services, have also added pressure, as emergency departments are responsible for 40% to 70% of all hospital admissions [33], and over 50% of patients seen in these departments now obtain imaging in one form or another [34].

In response, many academic centers and large hospitals have shifted away from a system where emergency physicians or residents originally read films (later over-read by general radiologists), toward one in which "ER-dedicated" radiologists perform and interpret all imaging day and night. These "ER-dedicated" radiologists possess emergency radiology fellowship training and/or center their practices on the radiological care of the injured and acutely ill. To facilitate this transition, some hospitals have placed radiological facilities, and even entire radiology departments, within or adjacent to emergency centers [33]. Academic programs have begun to emphasize emergency radiology as a unique discipline, with approximately 40% of programs teaching it as a separate section with its own curriculum [34,35]. In addition, several programs now offer fellowships in emergency radiology. The American Society of Emergency Radiology was established in 1988 in order to foster the growth of emergency radiology, and it now boasts over 450 members.

Most studies to date regarding emergency department radiology coverage have focused solely on academic centers [34-37], with very little being published about private, community hospitals. Community hospitals often face different needs and constraints than do academic centers due to their generally smaller sizes, different patient populations, and financial limitations. It is hoped that this study has described the ways in which community hospitals have organized emergency department radiology coverage to cope with the present shortage of diagnostic radiologists, especially ER-dedicated ones.

Analysis of Findings

This study has uncovered great variation in the current provision of imaging interpretation services, independent of emergency department size, geographic location, or trauma center designation. The 97 departments surveyed utilized over a dozen distinct coverage arrangements: differing in their assignment of daytime image interpretation, use of teleradiology services, and night-time radiologist consult capabilities. Analysis of the data—especially when categorized by

trauma center designation—does suggest several possible trends (outlined in the results section). A number of broad and tentative conclusions can be drawn from the results, although the presence of unexplained variation means that his study has not achieved a full understanding of overall coverage patterns.

First, emergency departments tend to assign plain film interpretation differently from CT scan and sonogram interpretation duties, placing extra emphasis in having a radiologist read advanced studies. Radiologists perform primary daytime plain film interpretation at only 40.2% of community hospitals, but almost always initially read CT scans (93.8%) and sonograms (93.1%), once considered an area of contention. Furthermore, many small hospitals without full-time radiologists on-site described using teleradiology services to ensure that radiologists read advanced studies in time for patient management. Results from papers investigating academic centers, in comparison, are varied. A 1992 study reported that radiologists performed initial daytime radiograph interpretations at 77% of academic centers [36], while a more recent paper suggests that emergency physicians now carry out this function at 66% of centers [37]. No academic center data are available for initial CT scan and sonogram interpretation.

Second, even low volume community hospitals currently utilize an impressive level of information technology, with greater than 70% of low-volume departments benefiting from night-time teleradiology services. Most emergency physicians expressed satisfaction with teleradiology, but a few complained about their inability to transmit plain films when consult was required. Quality transmission of plain films was most directly tied to the presence of digital radiography, which allows emergency physicians to send questionable plain films via PACS to radiologists outside the department. Secondarily digitizing and transmitting plain films obtained conventionally often resulted in digital image resolution too poor to be of use.

Third, irrespective of volume or trauma center designation, very few emergency departments in community hospitals (only 2.1%) used "ER-dedicated" radiologists to perform emergency radiology work. This finding is in stark contrast to academic centers, where a year 2000 survey by the American Society of Emergency Radiology noted that emergency radiologists interpret emergency studies at 51% of responding radiology departments and that, on average, 2.3 full-time equivalent emergency radiologists are assigned to each academic emergency center [34, 35]. The reasons for this discrepancy are varied. Many smaller emergency departments in our survey reported that their imaging volumes were not large enough to justify an "ER-dedicated" radiologist; a few felt that emergency physicians and general radiologists were just as qualified; whereas others lacked funding to pursue additional radiologists. At the same time, many ER-fellowship trained radiologists may prefer to remain in academic centers, which are better structured to make full use of their expertise and services.

Fourth, it appears that staffing needs become more pronounced as emergency department size increases. Trauma centers and high-volume departments reported the highest levels of ER-perceived radiology staffing shortages, at around 32% (versus 15-20% for low-volume and non-trauma centers). These differences are not great, though. One explanation for this difference may be that smaller hospitals have lower imaging volumes, which can be more easily handled by the covering general radiologist. Larger hospitals reported becoming overwhelmed mainly on nights when multiple, complicated patients arrived simultaneously with only one radiologist on-duty to assist. It is important to realize that this staffing question was not asked of radiology groups, but of emergency departments, which are likely to feel shortages only after other radiologists in the group are unable to pick up the slack. Therefore, this finding relates more to how the emergency radiologist shortage (outlined in the previous HWI papers [11, 13]) is impacting patient care, as opposed to radiology group workloads.

Survey Limitations

There are several limitations of our study, which deserve exploration. First, with only 97 surveyed hospitals, statistical significance of modest-sized differences is low. Limiting the sample was done on purpose to achieve a study-size that was replicable and manageable, but at the same time sufficient to draw general conclusions. Subsequent surveys can use similar size and compare. Second, this study does not address the role of billing limitations or perform a cost-effectiveness analysis. Finally, administering the questionnaire to radiologists, who sometimes possess different views than emergency physicians, might have yielded different answers, especially with regard to staffing needs.

Radiologists might also have been able to provide more accurate and detailed explanations of the services that they offer and of who provides them. Unfortunately, such a study was not possible, since many smaller hospitals did not possess in-house radiology departments. Emergency departments were the units of interest in this study, and so questions were asked of emergency service providers. Nevertheless, only data from interviewees who were confident in their answers were included in the results. This study was more concerned with obtaining a candid assessment of the value of emergency radiology services as perceived from the outside than outlining what radiologists themselves believe. Only by understanding clearly how we do or do not fulfill the needs of others, can we optimize the services that we provide. It is worth noting that this study provides information—such as initial sonography coverage—not addressed by previous studies despite much concern over this topic.

Implications

A discussion of who interprets emergency films and images is especially important because this concept lies directly at the heart of the issues of standard of care and self-referral. Self referral—which is the practice of non-radiologists ordering, interpreting, and collecting reimbursement on

imaging studies for their own patients—has repeatedly been shown to result in higher misinterpretation rates, higher costs, higher imaging utilization rates, poorer technical quality, and less patient safety [38, 39]. Numerous studies have also revealed that interpretations by emergency physicians, in specific, are less accurate, less sensitive, and less specific than those of radiologists [38, 40-43]. One study even suggested that emergency physicians' performances fail to improve with increasing experience [44], and perhaps are more related to limits in imaging training. Therefore, it is somewhat disconcerting that radiologists primarily interpret plain films in only 40% of private hospital emergency departments. In fairness, emergency physicians point out that very few of these mistakes (between 0.2% to 1.1%) lead to changes in patient management [42, 45, 46]. Nevertheless, it is still vital for both quality patient care and cost-control that radiologists, not emergency physicians, control and interpret emergency studies whenever possible. As a specialty, it is our responsibility to inform and formulate the appropriate standard of care regarding imaging services and to provide for them in a cost-effective manner.

Although emergency CT and sonogram interpretation are mostly in the hands of radiologists, emergency plain film interpretation is still at issue. This has intensified recently, as HCFA (the Health Care Financing Administration; now CMS, the Center for Medicare and Medicaid Services) in 1995 mandated that it would reimburse only one professional fee for interpreting each image, giving priority to the physician who supplies the initial report [46]. When asked specifically about plain film interpretation, several emergency physicians volunteered that they were dissatisfied with the services provided by radiologists, citing long turnaround times and minimal discordance in interpretations. They also gripe about lack of availability of radiologists during nights and weekends. As a result, a few of these emergency physicians have recently reverted to performing initial radiograph interpretations themselves.

Thus, a central issue appears to involve freeing up radiologists to perform emergency services in a timely manner. Unfortunately, due to the current radiologist shortage, it will be very difficult to redirect practicing radiologists to work exclusively in the emergency department. As Mueller and Yu have pointed out in their recent paper [33], creating an in-house, separate, dedicated emergency radiology section may require from four to six additional radiologists on staff. Emergency department imaging volumes must be able to support these radiologists, so that their salaries do not overweigh the quality and efficiency benefits provided by their presence.

All else being equal, a dedicated emergency radiology service is preferable to general radiologist coverage, which is preferable to emergency physicians reading their own films. A recent study by Yoon et. al. recently demonstrated that, even among attending radiologists, the use of subspecialists for emergency department imaging interpretation results in a 30% discordance rate as compared to general radiologists and also modestly improved patient care [48]. In the community setting, the key is to make such a preferred situation feasible within the constraints of the hospital.

Potential Solutions

Trauma centers and high-volume centers may want to create emergency radiology sections, analogous to the Mueller-Yu model [33], and employ "ER-dedicated" radiologists 24 hours a day. These emergency centers, similar to academic centers, tend to have the most acute staffing needs, greatest imaging volumes, most financial resources, and largest radiology departments. Thus, they are most in need of and would be best able to support free-standing emergency radiology services. Liberating non-ER radiologists to perform their work without interruption should increase efficiency and counteract the cost of having to hire additional personnel.

On the other hand, such in-house emergency radiology sections may not be feasible for medium and low volume centers. Many small hospital emergency departments are satisfied with their current radiology coverage, as their general radiologists are available often enough to provide quality service in a timely manner. Those that are dissatisfied may want to consider instituting daytime teleradiology services in addition to their night-time coverage. Small hospitals that lack in-house radiology departments have already done so for CT scans and sonograms. As PACS systems and digital radiography proliferate and information flow rates improve, the majority of hospitals will soon be able to transmit all radiographs—in addition to CT scans, sonograms, and nuclear studies— making teleradiology a more attractive option. In this manner, the 8% of departments currently without night-time radiology coverage and the 62% lacking night-time radiograph consult capability could also gain coverage via teleradiology. It is important to realize, though, that there is definitely a difference between being available on-site and providing primary interpretation only (either from on-site or afar). This is an area where turf could erode our importance.

Interestingly, radiologists today are positioning themselves to take advantage of current technological and structural changes by creating off-site emergency radiology practices. These offsite groups can pool demand from several low volume departments, allowing fewer radiologists to cover a greater number of hospitals, thus alleviating some of the staffing shortages. In fact, some radiology groups are already forming and basing themselves overseas to take advantage of the time zone differences for United States night-time work. Barriers do exist though, as state licensing requirements and other issues so far have kept overseas operations more a pilot project than an industry. Regardless, by recruiting "ER-dedicated" radiologists, these teleradiology groups, whether based at home or overseas, can provide expert service and further improve patient care. Through 24-hour in-house coverage and/or comprehensive teleradiology

services, "ER-dedicated" radiologists may someday be able to read all emergency studies at all hospitals, day and night.

Radiologists in all settings can help drive improvements in the delivery of emergency radiology services. Academic programs can continue to refine emergency radiology as a separate discipline. Private groups can further embrace technological advances and improve communication systems. Health services researchers can continue to document the efficiency and quality improvements resulting from subspecialist imaging interpretation. Radiology organizations can then emphasize these benefits to hospitals and government officials to help them develop policies addressing self-referral and departmental organization.

In summary, most community hospitals, even large ones, lack dedicated emergency radiology sections, which are now prevalent in over 50% of academic centers. In addition, emergency physicians perform primary plain film interpretations in over 60% of such emergency departments, despite that fact that radiologists can perform this work in a more accurate and cost-effective manner. Currently, there exists great variability in the delivery of emergency radiology services from one hospital to another. Although emergency radiology sections may not be appropriate for all types of hospitals, the practice of emergency radiology does need to be standardized and implemented in a manner that will best serve the needs of the patients who depend on its services. Radiology department reorganization and technological advances should allow us to achieve these goals, but practicing radiologists need to continue taking an active role in implementing such changes.

Concluding Remarks

The current shortage of radiologists entering the workforce requires immediate attention for crafting a long-term solution, both for emergency radiology and all subspecialty fields. For the

well-being and the future of diagnostic radiology, we will need to supply an adequate number of well-trained radiologists to provide optimal patient care, to fight and win turf battles, and to allow us to expand with advances in imaging technology. We also need to reorganize our services so that we can continue to provide highest quality medical care until the workforce situation stabilizes. In other words, we must as a group act now to preserve our specialty in the future.

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Figure References and Legends

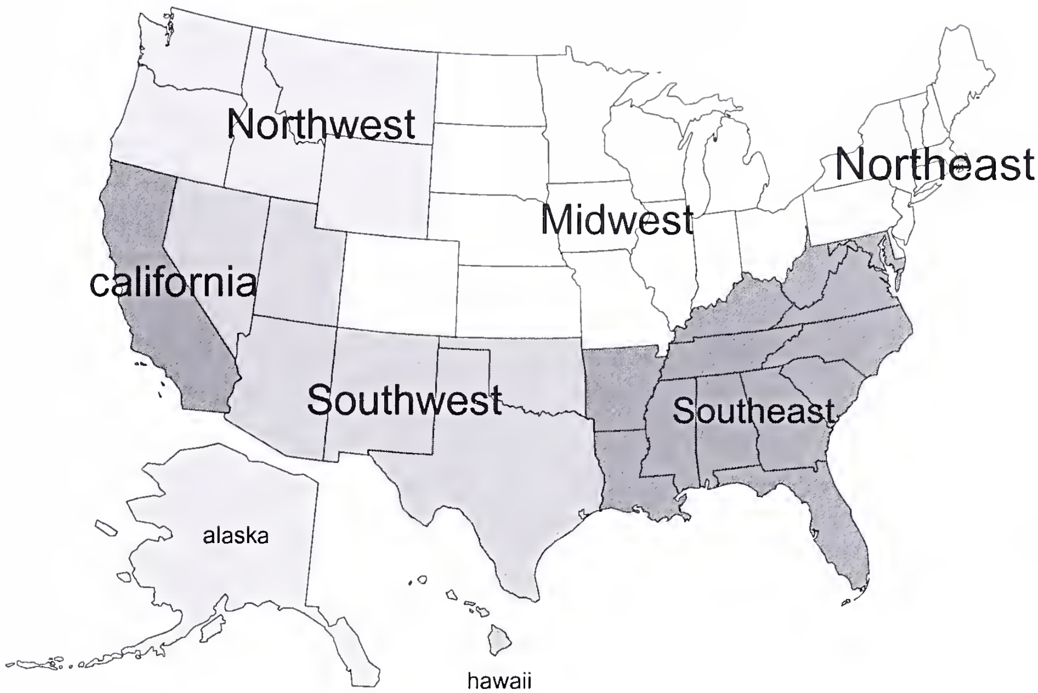

Fig 1.—Map of United States shows geographic regions used for coding of advertisements. Alaska is included in the Northwest and Hawaii in the Southwest.

EMERGENCY DEPARTMENT IMAGING INTERPRETATION SERVICES QUESTIONAIRRE[1]

1. During the day[2], who initially interprets ED radiographs? (1) Radiologists (2) Emergency Physicians

2. During the day[2], who initially interprets ED CT scans? (1) Radiologists (2) Emergency Physicians

3. During the day[2], who initially interprets ED sonograms? (1) Radiologists (2) Emergency Physicians

4. If ED physicians initially interpret radiographs, does a radiologist over-read every image at a later point? (1) yes (2) no

5. If radiologists initially interpret radiographs, do ER-dedicated radiologists[3] perform majority of the work? (1) yes (2) no

6. Who performs night-time radiology coverage?
   (1) In-house ER-dedicated radiologist
   (2) In-house non-ER-dedicated radiologist
   (3) Teleradiology for all images and plain films
   (4) Teleradiology for consult-only
   (5) No night-time radiology coverage

7. If you utilize teleradiology or nighthawk services for night-time coverage, do you have the ability to send plain films and CT scans or CT scans only? (1) plain films (2) CTs only

8. From the viewpoint of the emergency department staff, does your emergency department currently have a staffing need for radiologists that cover the ED? (1) yes (2) no

9. If you do have staffing need, are you currently recruiting for ER-dedicated radiologists? (1) yes (2) no

[1] *In addition, for each emergency department contacted, information pertaining to the number of ER beds, number of ER patient visits per year, and trauma center designation was collected from interviewees.*

[2] *For clarification, "day" or "daytime" was defined to respondents as "Monday through Friday / 9am to 4pm".*

[3] *Also for clarification, an ER-dedicated radiologist was defined to respondents as either an ER fellowship-trained radiologist or a non-ER radiologist who spends more than 50% of his time exclusively interpreting emergency department studies.*

Fig 2.—Telephone questionnaire administered to physician-directors or nurse-managers of the emergency departments at randomly sampled private, community hospitals.

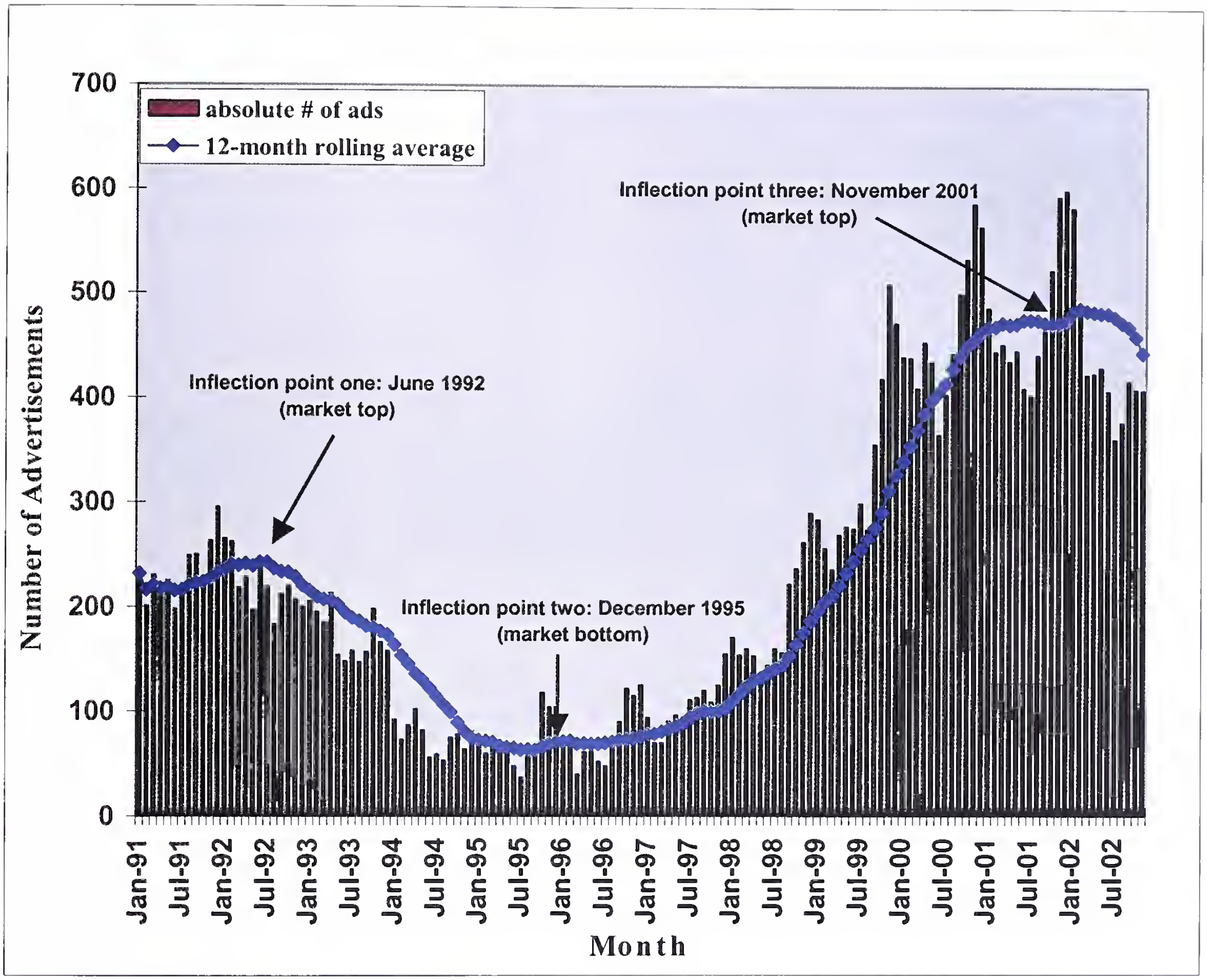

Fig 3.—Graph shows actual number of advertisements *(bars)* per month in *American Journal of Roentgenology* and *Radiology* from January 1991 through December 2002, with 12-month rolling average *(thick line)* calculated to reduce seasonal variation. Note that the rolling average peaked in the summer of 1992, bottomed out at the end of 1995, and peaked again during the fall of 2001. There is a clear downtrend in the rolling average from February to December 2002. Jan = January, Jul = July.

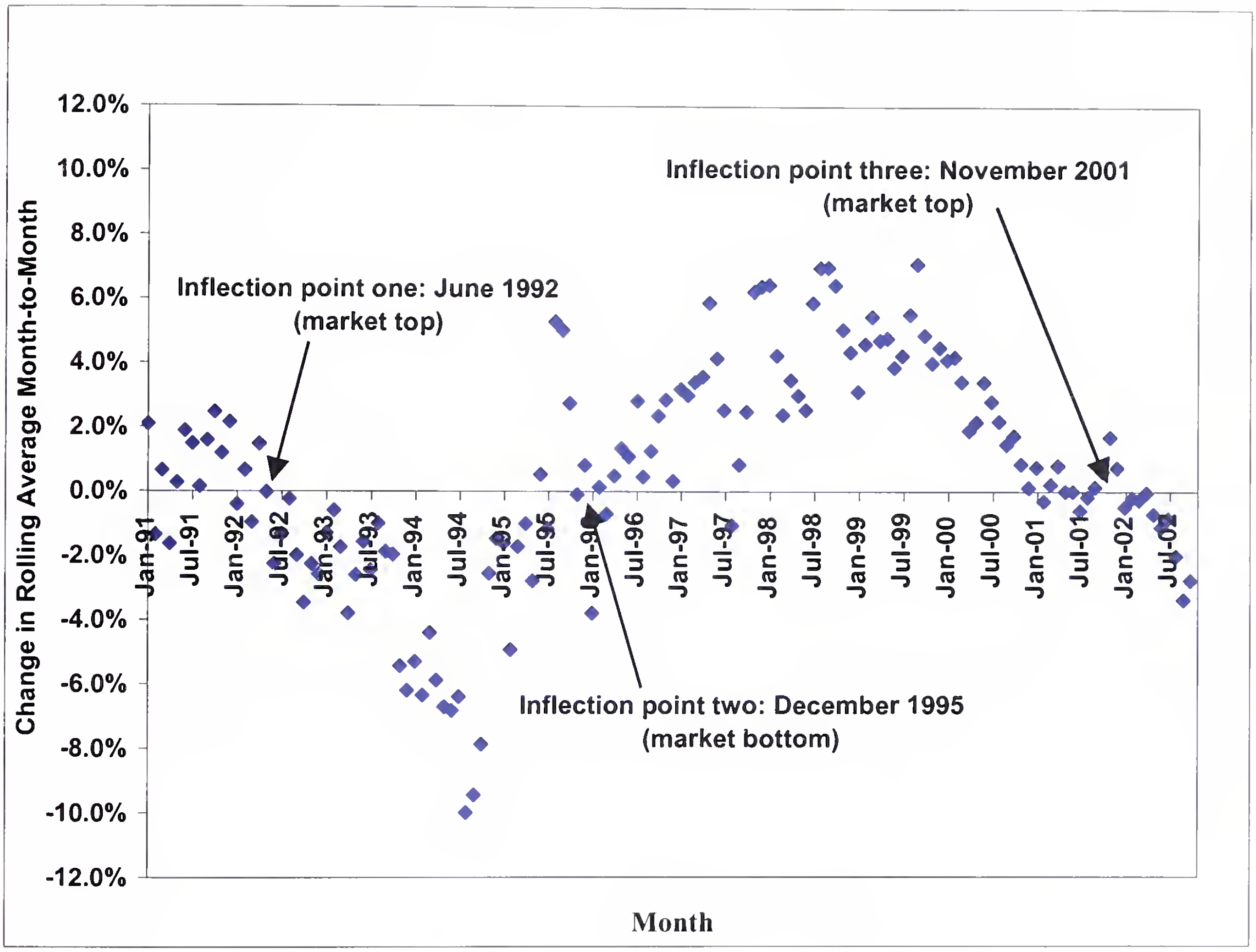

Fig 4.—Scatterplot shows percentage of change month-to-month using the rolling average data seen in Figure 3. Note three inflection points: June 1992 when percentage of change switches from positive to negative; December 1995 when percentage of change switches from negative to positive; and November 2001 when percentage of change switches from positive back to negative. Jan = January, Jul = July.

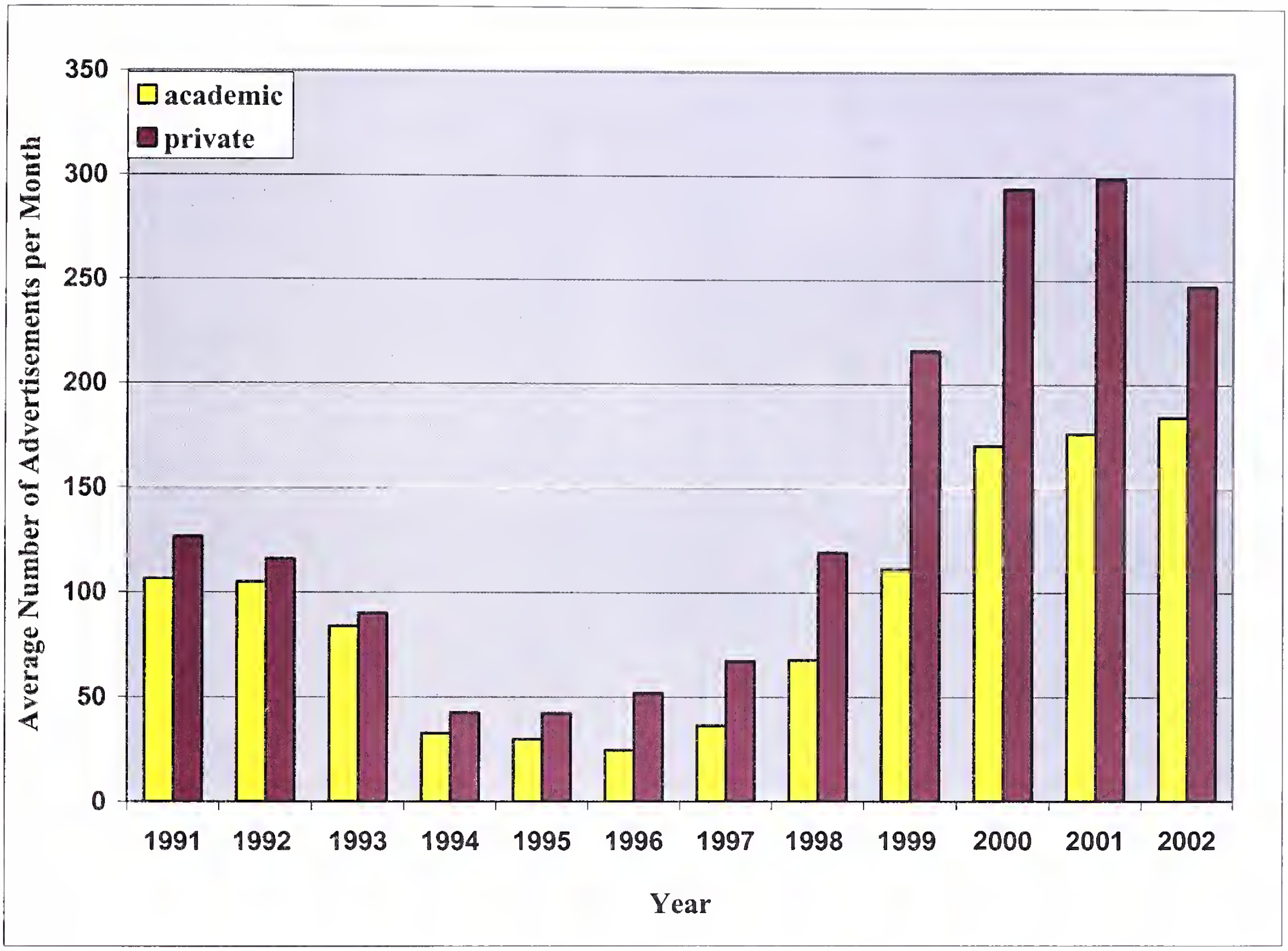

Fig 5.—Bar graph shows the average number of want ads per month in *American Journal of Roentgenology* and *Radiology* for diagnostic radiologists sorted by practice type, from January 1991 through December 2002. Note that the gap between the number of private *(purple bars)* and academic *(yellow bars)* positions decreased for 2002 versus 2001.

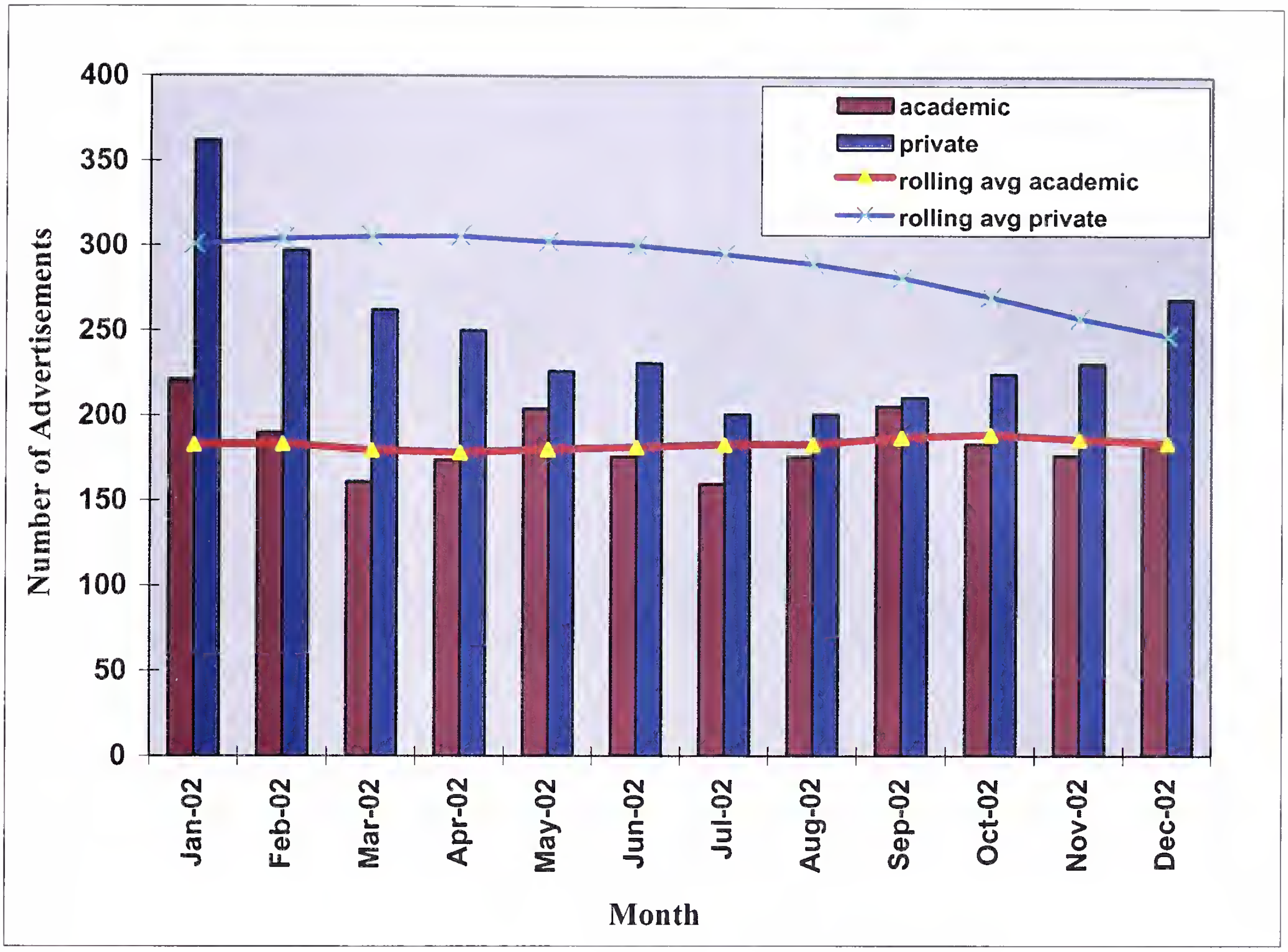

Fig 6.—Graph shows number of private *(blue bars)* and academic *(purple bars)* positions advertised per month from January 2002 through December 2002. Twelve-month rolling averages for private *(blue thick line)* and academic *(red thick line)* positions are superimposed. Note the rolling averages for private and academic positions converge as the year progresses, as the number of private positions decreases and the number of academic positions increases.

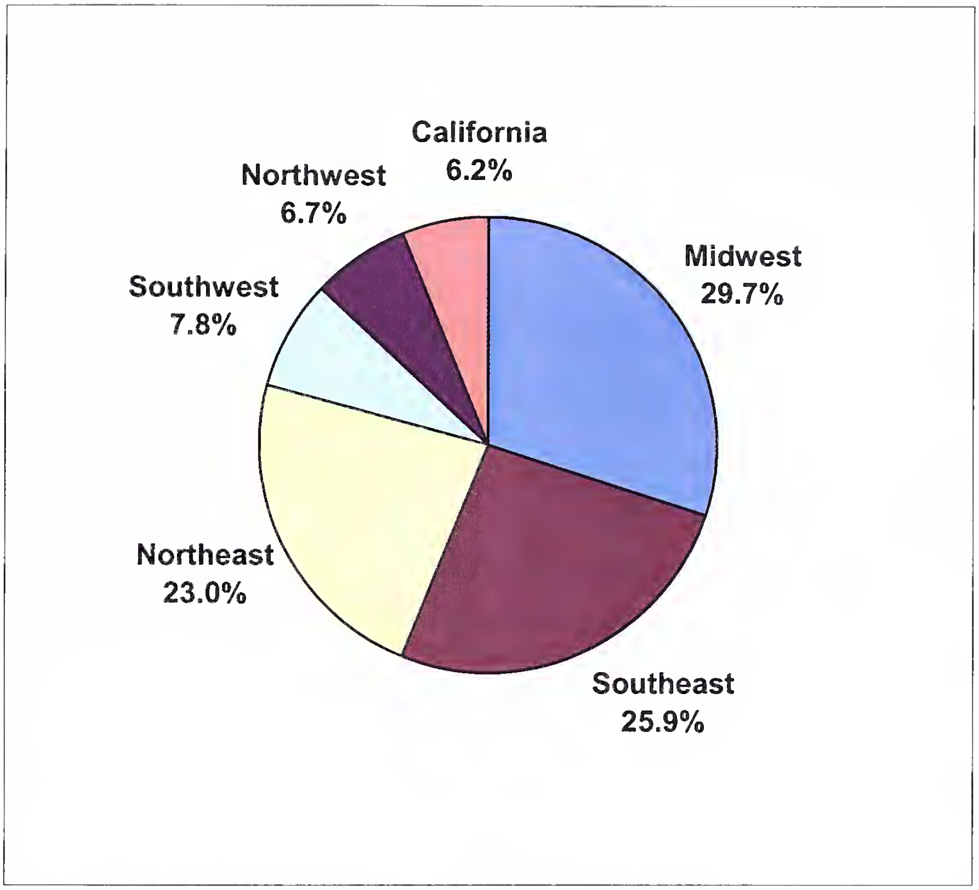

Fig 7.—Pie chart shows the percentage of total positions advertised by geographic location for the four-year period from January 1999 through December 2002.

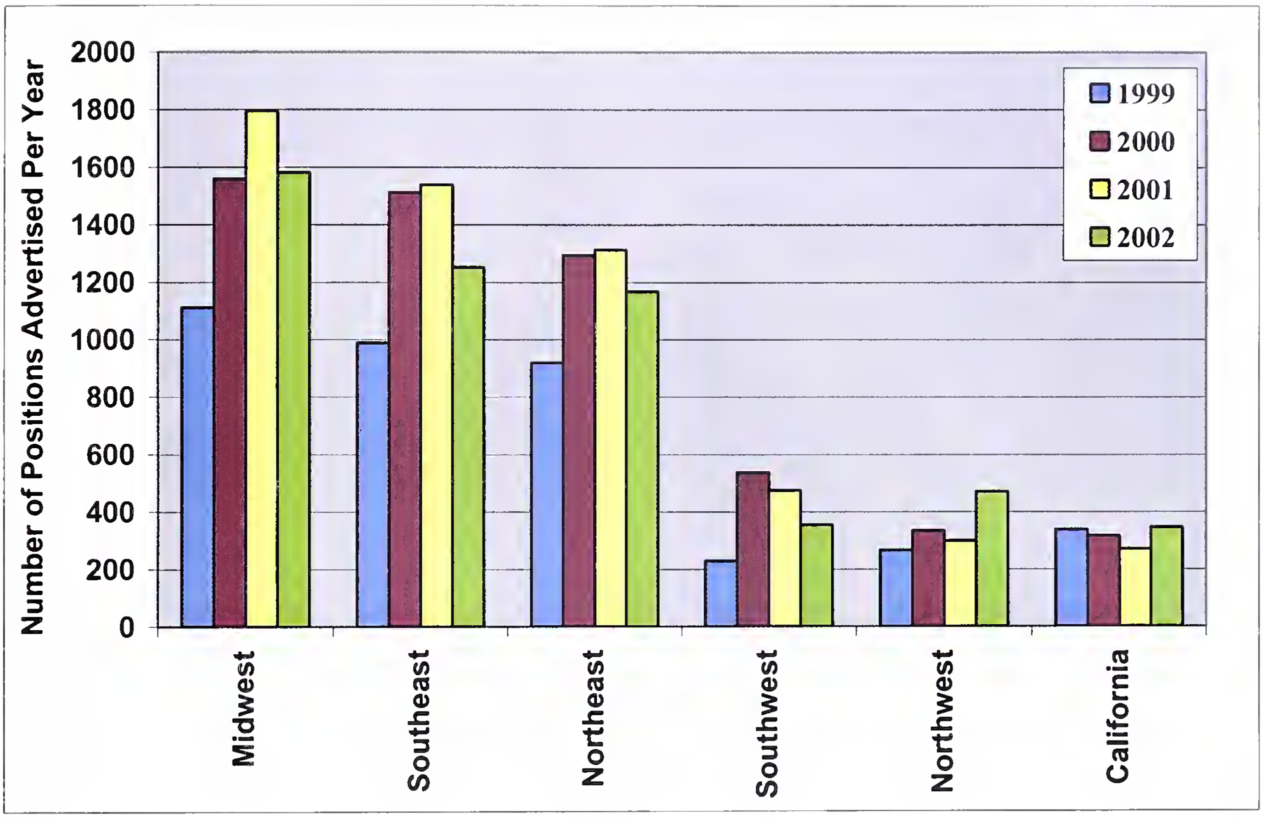

Fig 8.—Bar graph shows the yearly absolute number of positions advertised for each geographic region from 1999 through 2002. Note that the number of ads decreased in the Midwest, Southeast, Northeast, and Southwest for 2002 versus 2001, but rose in the Northwest and California.

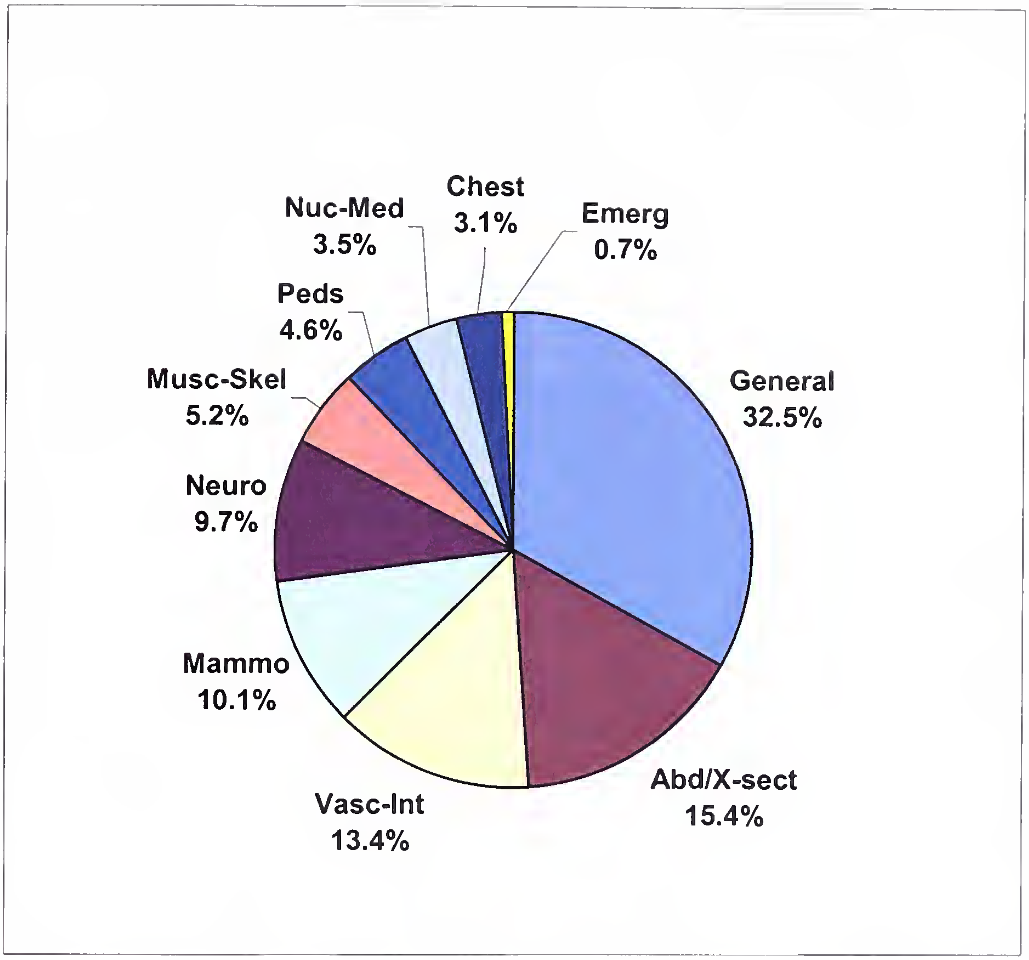

Fig 9.—Pie chart shows percentage of total positions advertised by subspecialty for the four-year period from January 1999 through December 2002. Abd/X-sect = abdominal and cross-sectional radiology, Vasc-Int = vascular and interventional radiology, Mammo = mammography, Neuro = neuroradiology, Musc-Skel = musculoskeletal radiology, Peds = pediatric radiology, Nuc-Med = nuclear medicine, Emerg = emergency radiology.

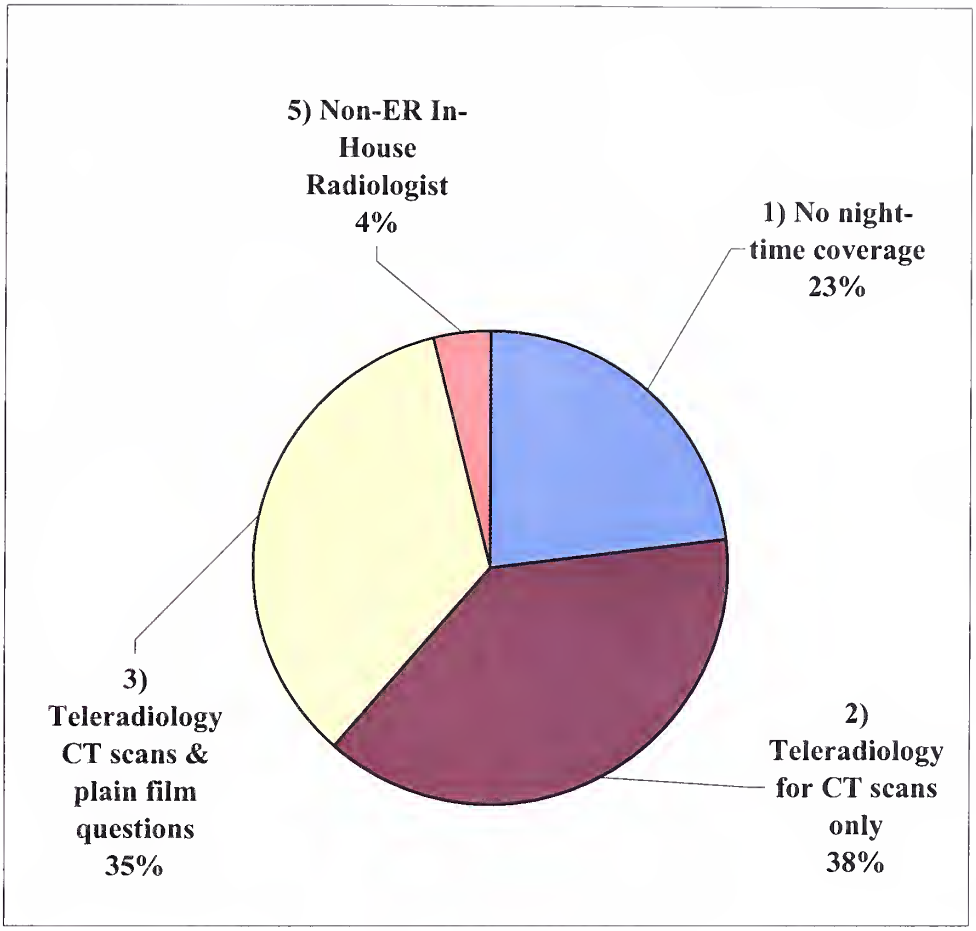

Fig 10.—Pie chart shows the night-time radiology coverage distribution for emergency departments surveyed with volumes of less than 10,000 patients per year. Note that zero of the emergency departments employed teleradiology for all CT scans and all plain films.

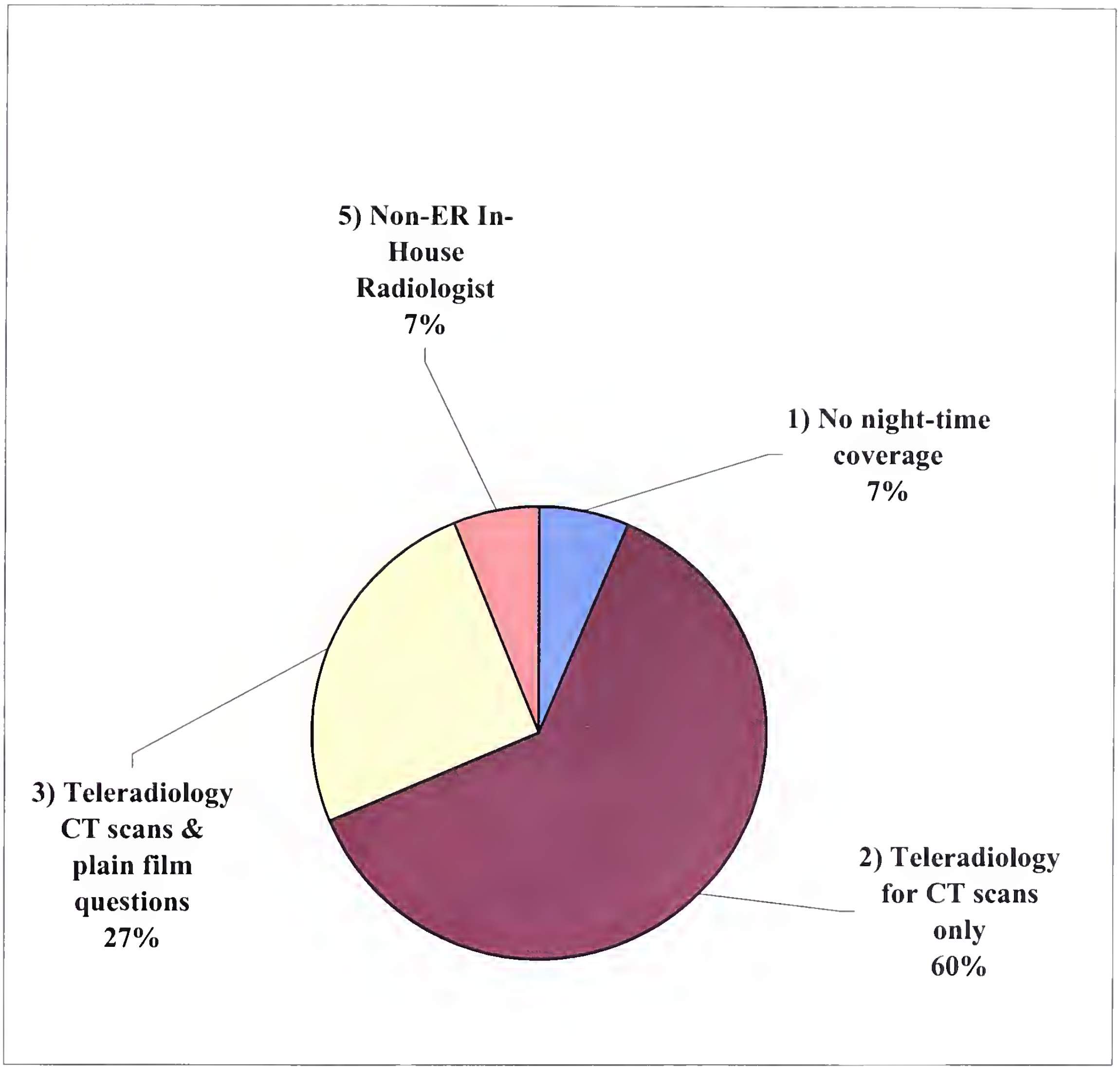

Fig 11.—Pie chart shows the night-time radiology coverage distribution for emergency departments surveyed with volumes of between 10,000 to 25,000 patients per year. Note that zero of the emergency departments employed teleradiology for all CT scans and all plain films.

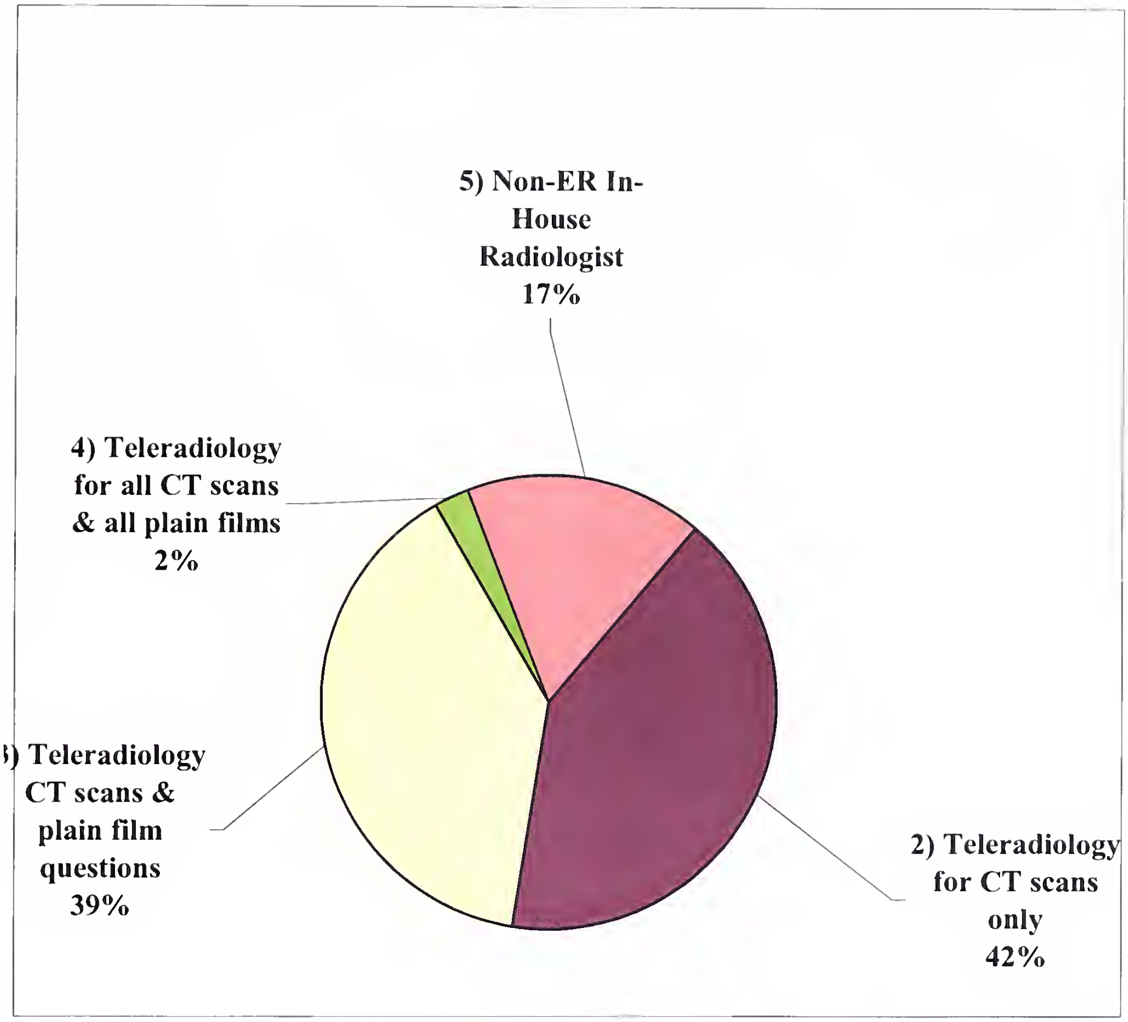

Fig 12.—Pie chart shows the night-time radiology coverage distribution for emergency departments surveyed with volumes of greater than 25,000 patients per year. Note that all of the emergency departments possessed either a non-ER dedicated, in-house radiologist or utilized teleradiology services of one form or another.

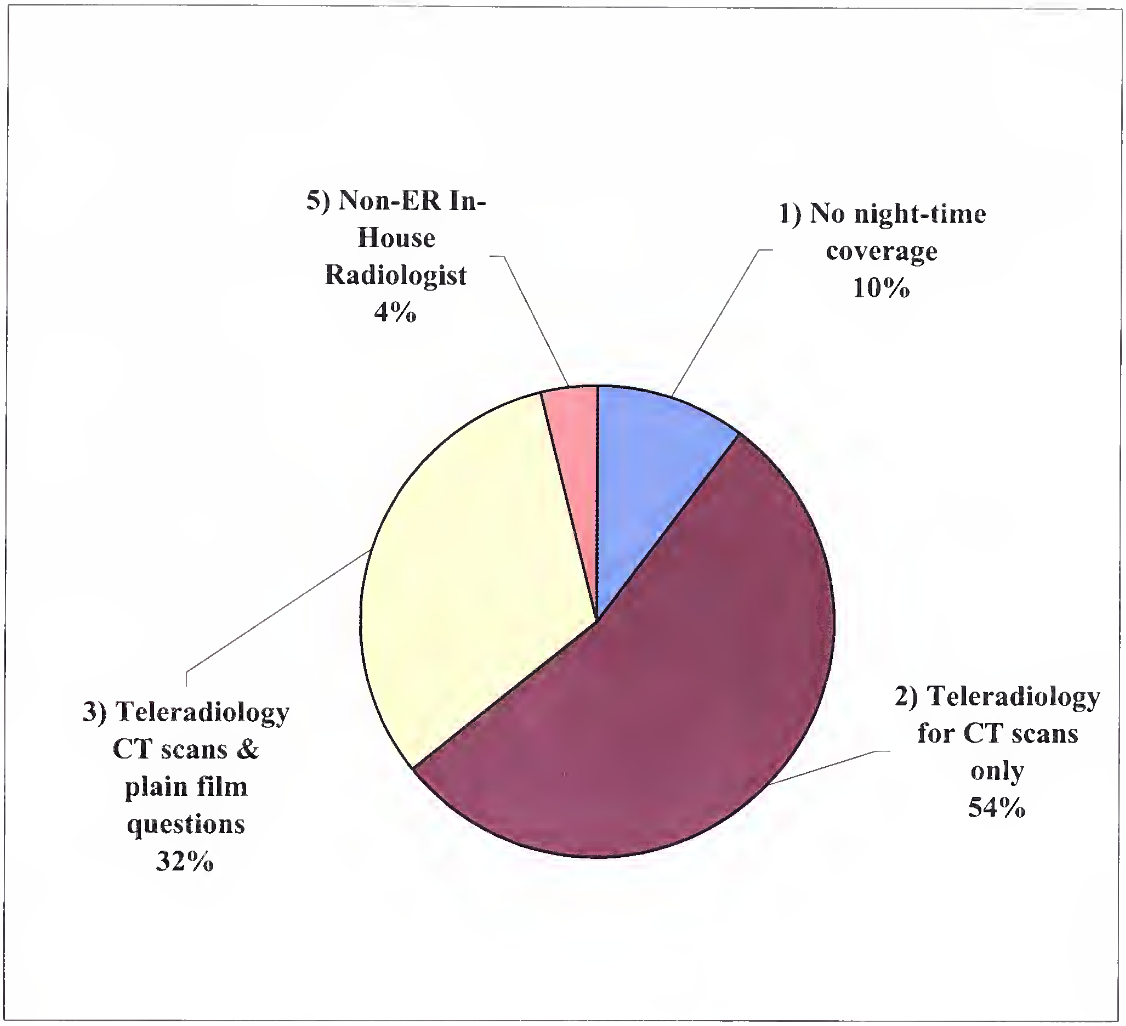

Fig 13.—Pie chart shows the night-time radiology coverage distribution for the 78 non-trauma centers surveyed. Note that zero of the emergency departments employed teleradiology for all CT scans and all plain films.

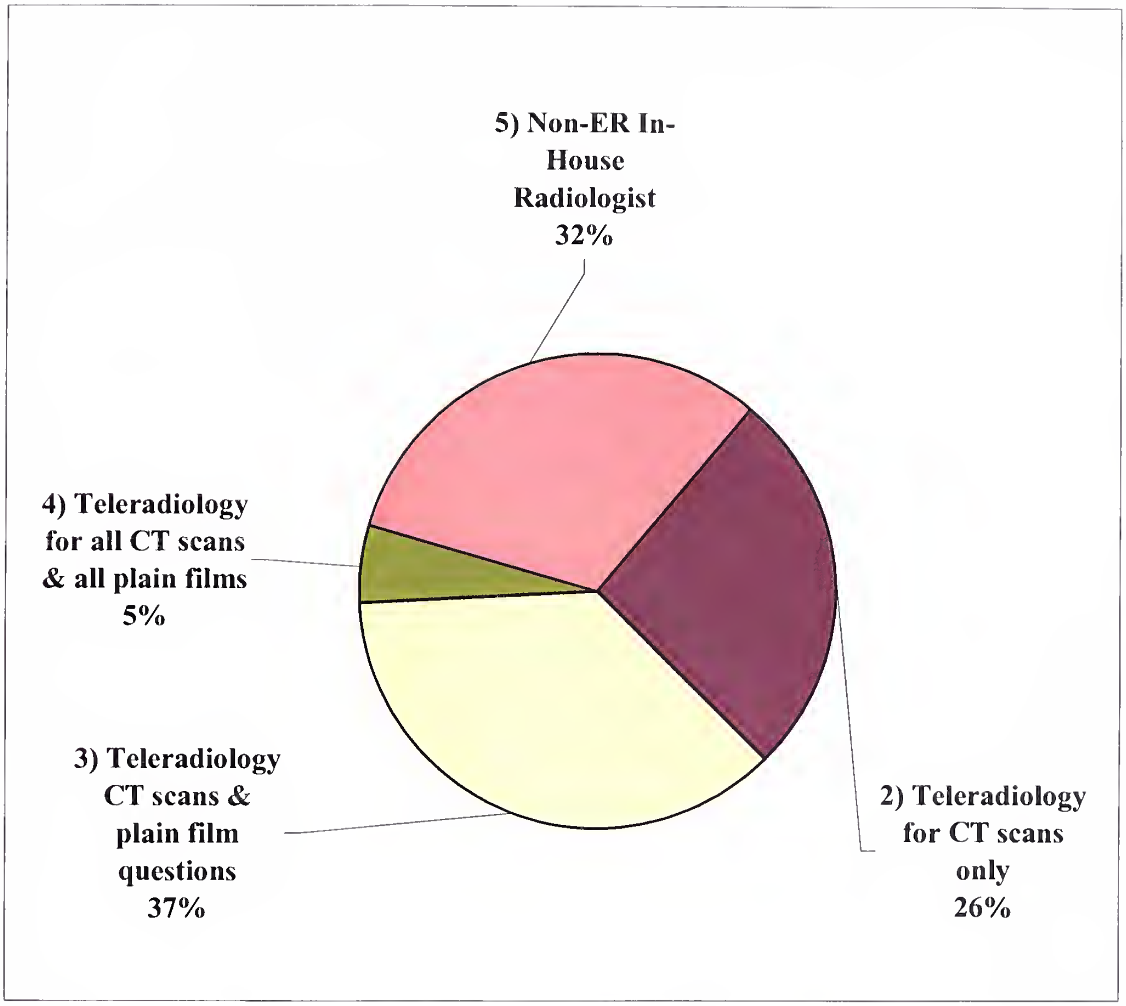

Fig 14.—Pie chart shows the night-time radiology coverage distribution for the 19 level 2 trauma centers surveyed. Note that all of the emergency departments possessed either a non-ER dedicated, in-house radiologist or utilized teleradiology services of one form or another.

Tables

TABLE 1: HELP-WANTED ADVERTISEMENTS FOR DIAGNOSTIC RADIOLOGISTS BY GEOGRAPHIC LOCATION FROM JANUARY 1991 THROUGH DECEMBER 2002[A]

Years	MW	SE	NE	SW	NW	CAL	OTHER[B]
January 1991 – December 1994	1,343 *(15.9%)*	2,327 *(27.6%)*	2,309 *(27.4%)*	1,042 *(12.4%)*	631 *(7.5%)*	693 *(8.2%)*	91 *(1.0%)*
January 1995 – December 1998	1,179 *(22.4%)*	1,383 *(26.3%)*	1,358 *(25.8%)*	515 *(9.8%)*	341 *(6.5%)*	331 *(6.3%)*	156 *(3.0%)*
January 1999 – December 2002	6,059 *(29.7%)*	5,295 *(25.9%)*	4,695 *(23.0%)*	1,598 *(7.8%)*	1,371 *(6.7%)*	1,275 *(6.2%)*	78 *(0.5%)*
P-value	**<.001**	**NS**	**<.001**	**<.001**	**NS**	**NS**	------

[A]Note.—Data are expressed as number and percentage of ads; geographic location categories are listed in order of prevalence for most recent 4-year period; p-values reflect comparison between percentages of ads in each category for January 1999-December 2002 versus January 1995-December 1998.

[B] "Other" category includes foreign advertisements and positions of indeterminate location.

MW = Midwest, SE = Southeast, NE = Northeast, SW = Southwest, NW = Northwest, CAL = California.

TABLE 2: HELP-WANTED ADVERTISEMENTS FOR DIAGNOSTIC RADIOLOGISTS BY SUBSPECIALTY FROM JANUARY 1991 THROUGH DECEMBER 2002[A]

Years	GEN	ABD	V/I	MAM	NEURO	MS
January 1991 – December 1994	3,657 *(43.4%)*	1,155 *(13.7%)*	855 *(10.1%)*	496 *(5.9%)*	689 *(8.2%)*	395 *(4.7%)*
January 1995 – December 1998	2,090 *(39.7%)*	538 *(10.2%)*	861 *(16.4%)*	439 *(8.3%)*	447 *(8.5%)*	254 *(4.8%)*
January 1999 – December 2002	6,635 *(32.5%)*	3,143 *(15.4%)*	2,729 *(13.4%)*	2,068 *(10.1%)*	1,974 *(9.7%)*	1,068 *(5.2%)*
P-value	<.001	<.001	<.001	<.001	<.005	NS

Years	PEDS	NUC-M	CHEST	EMERG	P/T[B]	OTHER[B]
January 1991 – December 1994	373 *(4.4%)*	136 *(1.6%)*	296 *(3.5%)*	94 *(1.1%)*	----- *N/A*	216 *(2.6%)*
January 1995 – December 1998	143 *(2.7%)*	154 *(2.9%)*	111 *(2.1%)*	54 *(1.0%)*	----- *N/A*	178 *(3.4%)*
January 1999 – December 2002	941 *(4.6%)*	725 *(3.5%)*	623 *(3.1%)*	151 *(0.7%)*	143 *(0.7%)*	224 *(1.1%)*
P-value	<.001	<.05	<.001	<.05	-----	-----

[A]Note.—Data are expressed as number and percentage of ads; subspecialty categories are listed in order of prevalence for most recent 4-year period; p-values reflect comparison between percentages of ads in each category for January 1999-December 2002 versus January 1995-December 1998.

[B] "Part-time" ads were not included in data for first two 4-year periods; "other" category includes research, administrative, and chair positions. GEN = general radiology, ABD = abdominal and cross-sectional radiology; V/I = vascular and interventional radiology; MAM = mammography, NEURO = neuroradiolgy, MS = musculoskeletal radiology, PEDS = pediatric radiology, NUC-M = nuclear medicine, EMERG = emergency radiology; P/T = part-time position.

TABLE 3: EMERGENCY DEPARTMENT IMAGING INTERPRETATION SERVICES SURVEY RESULTS BROKEN DOWN BY DEPARTMENT PATIENT VOLUMES[A]

CHARACTERISTICS	TOTAL	Low Vol	Med Vol	High Vol	p-value
Number of ERs responding	*97*	*26*	*30*	*41*	-------
1) Radiologist day-time initial plain film interpretation	40.2%	26.9%	56.7%	36.6%	*0.0635*
2) Radiologist day-time initial CT scan interpretation	93.8%	88.0%	96.7%	97.6%	*0.2033*
3) Radiologist day-time initial sonogram interpretation	93.1%	87.0%	93.3%	96.3%	*0.3641*
4) Radiologist over-reads films read first by ER physician	100.0%	100.0%	100.0%	100.0%	*N/A*
5) ER-dedicated radiologist performs ER work	2.1%	0.0%	3.3%	2.4%	*0.6648*
6) Night-time plain film consult capability	38.1%	34.6%	30.0%	46.3%	*0.3416*
7) Night-time CT scans read immediately by radiologists	91.6%	79.2%	93.3%	97.6%	***0.0331***
8) ER radiologist staffing need/shortage (viewpoint of ER)	23.7%	15.4%	23.3%	31.7%	*0.3130*

[A]Note.—"Low volume" emergency departments are defined as departments that see fewer than 10,000 patients per year, "medium volume" as those that see between 10,000 to 25,000 patients per year, and "high volume" as those that see greater than 25,000 patients per year.

TABLE 4: NIGHT-TIME RADIOLOGY COVERAGE PATTERNS BROKEN DOWN BY EMERGENCY DEPARTMENT PATIENT VOLUME[A]

NIGHT-TIME RADIOLOGY COVERAGE	TOTAL	Low Vol	Med Vol	High Vol
1) No night-time coverage	8.2%	23.1%	6.7%	0.0%
2) Teleradiology for CT scans only	48.5%	38.5%	60.0%	41.5%
3) Teleradiology CT scans & plain film questions	33.0%	34.7%	26.7%	39.0%
4) Teleradiology for all CT scans & all plain films	1.0%	0.0%	0.0%	2.4%
5) In-house, non-ER-dedicated radiologist	9.3%	3.8%	6.7%	17.1%
	100.0%	*100.0%*	*100.0%*	*100.0%*

[A]Note.— "Low volume" emergency departments are defined as departments that see fewer than 10,000 patients per year, "medium volume" as those that see between 10,000 to 25,000 patients per year, and "high volume" as those that see greater than 25,000 patients per year.

TABLE 5: EMERGENCY DEPARTMENT IMAGING INTERPRETATION SERVICES SURVEY RESULTS BROKEN DOWN BY TRAUMA CENTER DESIGNATION STATUS

CHARACTERISTICS	TOTAL	Non-trauma	Trauma	p-value
Number of ERs responding	*97*	*78*	*19*	--------
1) Radiologist day-time initial plain film interpretation	40.2%	37.2%	52.6%	*0.2180*
2) Radiologist day-time initial CT scan interpretation	93.8%	92.2%	100.0%	*0.2089*
3) Radiologist day-time initial sonogram interpretation	93.1%	91.3%	100.0%	*0.1835*
4) Radiologist over-read of films read first by ER physician	100.0%	100.0%	100.0%	*N/A*
5) ER-dedicated radiologist performs ER work	2.1%	1.3%	5.3%	*0.2735*
6) Night-time plain film consult capability	38.1%	33.3%	57.9%	***0.0481***
7) Night-time CT scans read immediately by radiologists	91.6%	90.8%	94.7%	*0.5795*
8) ER radiologist staffing need/shortage (viewpoint of ER)	23.7%	21.8%	31.6%	*0.3686*

TABLE 6: NIGHT-TIME RADIOLOGY COVERAGE PATTERNS BROKEN DOWN BY TRAUMA CENTER DESIGNATION STATUS

NIGHT-TIME RADIOLOGY COVERAGE	TOTAL	Non-Trauma	Trauma
1) No night-time coverage	8.2%	10.3%	0.0%
2) Teleradiology for CT scans only	48.5%	53.8%	26.3%
3) Teleradiology CT scans & plain film questions	33.0%	32.1%	36.8%
4) Teleradiology for all CT scans & all plain films	1.0%	0.0%	5.3%
5) In-house, non-ER-dedicated radiologist	9.3%	3.8%	31.6%
	100.0%	*100.0%*	*100.0%*