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Quantifying and Characterizing Trainee Participation in a Major Academic Radiology Department

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Objective: Trainees play an important role in the delivery of medical services in academic medical centers, yet the full extent of their contribution in radiology is unknown. The purpose of this study was to quantify trainee involvement in a single large academic radiology department.
Materials and Methods: In this Institutional Review Board-approved retrospective study performed in a tertiary care academic medical center, we identified the proportion of radiology reports with trainee involvement (by means of report co-signature) between July 2015 and June 2016. For each exam, we documented the modality, whether a trainee co-signed the report, and the division/subspecialty of the attending radiologist. We computed the overall proportion of radiology reports that involved a trainee and compared this proportion between imaging modalities, type of patient setting (Emergency Department, inpatient, outpatient), and across subspecialty divisions using Chi-square tests.
Results: Overall, we analyzed 607,074 radiology reports, of which trainees co-signed 239,187 (39.4%) reports. Trainee involvement varied considerably by division, ranging from 7.1% (ultrasound division) to 99.2% (cardiovascular imaging division) of reports, $P < 0.001$. Among diagnostic imaging modalities, trainee participation was highest in CT (67.0%) and MRI (60.9%) examinations, and lowest in ultrasound (15.3%), $P < 0.001$. Trainees were more involved in the emergency department (58.0%) and inpatient (43.4%) settings than in the outpatient setting (33.9%), $P < 0.001$.
Conclusions: Less than half of the imaging studies performed in an academic radiology department involved radiology trainees. Similar data and studies at other institutions may be useful to help define, monitor and improve optimal trainee education nationally.

Introduction

Academic medical centers depend in large part on trainees—defined as residents and fellows—to help care for patients. Radiology is no different. In 2011, approximately 15% of the total United States radiology workforce was comprised of radiology residents, a proportion that is even higher in academic medical centers.[1] In addition to participating in diagnostic and interventional services, radiology trainees provide offhour preliminary interpretations at the majority of academic medical centers, particularly for emergency department (ED) and hospitalized inpatients. [2]

Evidence suggests that radiology trainees are facing ever increasing workloads and pressures. In an analysis of Medicare data, trainee imaging workload increased by 26% from 1998 to 2010.[3] Radiology trainee case volume has increased over time in part due to increase in imaging utilization over the last several decades.[4–8] Not only are radiology departments experiencing higher imaging volumes, but there is also increasing pressure to reduce report turnaround times (RTAT), which may have unintended negative impacts on trainees. After the implementation of a 1-hour RTAT in one hospital's ED, residents felt that their education was negatively impacted in a significant way and faculty felt that the required RTAT negatively affected their ability to teach.[9]

In order to ease increasing pressures on all residency programs, not just in radiology, the Accreditation Council for Graduate Medical Education (ACGME) has created numerous residency guidelines including an 80 hour work week limit, no more than 6 consecutive nights of night float, and 14 duty free hours after a 24-hour call.[10] In addition, in order to potentially improve clinical care and trainee supervision and support, there has been an increasing call for continuous 24 hour, 7days/week attending radiology coverage at academic institutions.[11–15]

Despite the presumed importance of trainees in the provision of radiology services in academic medical centers, little information exists on the specific contribution of trainees to overall radiology services. In particular, the overall proportion of radiology studies that involve trainee participation in academic medical centers is unknown, as is how this proportion varies between departmental divisions, modalities, and patient setting (ED, inpatient, outpatient). The purpose of this study was to quantify trainee involvement in a single large academic radiology department.

Materials and Methods

Study Setting and Population

This study was approved by the Institutional Review Board at the study institution, a large, urban tertiary care hospital. From July 1,

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2015 to June 30, 2016, we retrospectively identified a total of 607,074 radiology reports that contained both attending and trainee and attending only signatures. The study population consisted of 211 attending radiologists and 92 trainees credentialed at the primary study institution's hospital or affiliated hospital and imaging sites. Trainees were identified by post graduate year (PGY) of training for the 2015 academic year and included 40 residents and 52 fellows. There were a total of 10 residents each from PGY-2 to PGY-5 years. The number of fellows varied by division and ranged from 2 (emergency radiology division) to 11 cardiovascular imaging division (CID). Our hospital offers 24 hour technologist coverage for computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, radiography, nuclear medicine, and emergent procedures. There is continuous 24 hour, daily attending radiology coverage in the ED.

During the 2015 academic year, residents spent roughly equivalent amounts of time in the musculoskeletal, ultrasound, breast imaging, nuclear medicine, interventional radiology, emergency, neuroradiology, and chest imaging divisions, averaging approximately 4 weeks per division annually. Residents spent proportionally greater time in the abdominal division and less time in the CID and at a dedicated oncologic imaging rotation at our affiliated cancer institute. Trainee imaging volume did not include 3 rotations during the third year: pediatric imaging performed off site at an affiliated children's hospital; advanced head and neck imaging, also at an affiliated center; and American Institute for Radiologic Pathology . All residents spend approximately 2 hours in formal didactic teaching each day as part of the residency program. Dedicated time for lectures and conferences for fellows varies by division. The curriculum is established by our internal education committee and is based on educational needs, taking into account the educational requirements established by the ACGME and the American Board of Radiology . Residents in our training program meet and surpass the minimum ACGME case log requirements, as required for successful completion of the program.

Call coverage, defined as after hours and weekend clinical coverage, was provided by in house residents (at the PGY-3 level and above), who performed preliminary interpretations on evening and overnight inpatient X-ray and CT studies. PGY-3, 4, and 5 residents spend approximately 4 weeks every year on this service. A subspecialty on call fellow reviews other inpatient studies, including MRI studies, when clinically necessary or when asked to assist the on call resident. On call subspecialty attending radiologists are available for consultation or emergent procedures at all times. Finalized reports are generated for overnight inpatient studies during routine daytime hours. Residents at the PGY-3 level and above also have a separate ED rotation. In this shift based rotation, residents generate finalized reports for ED patients that are signed by the attending 24/7.

Data Collection

For each imaging exam or procedure, we identified the modality of exam, the radiology subspecialty division in which the exam was performed or interpreted, whether the exam originated in the inpatient, outpatient, or ED setting, and if a trainee co-signed a report. Studies from all patient settings were included in our analysis.

Statistical Analysis

We computed the overall proportion of radiology reports that involved a trainee co-signature and compared this proportion between imaging modalities, patient setting, and across divisions. Chi-square tests were used for comparison of proportions across categories. The 95% confidence interval around reported means reflects 0.025 in each tail.

Results

Overall, 607,074 radiology reports were analyzed. Trainees (resident and fellows) were responsible for generating 39% (239,187/607,074) of preliminary reports (Fig 1), each reviewed and finalized by an attending radiologist. Of the studies read by trainees, fellows read nearly half of cases (114,809/239,187 reports; 48%). Residents were involved in 52% (124,378/239,187) of trainee reports, with first, second, and fourth year radiology residents involved in a similar percentage of cases, ranging from 13%-15%. Third year residents read a slightly lower percentage of cases at 9% (21,527/239,187), likely related to the higher percentage of time spent at offsite rotations during this year from which data was excluded from this study. Overall, residents read less than a quarter (20.5%) of the total number of reports read in the department in the 2015 academic year.

Trainee involvement varied considerably by modality (Fig 2). Ultrasound and mammography had the lowest rates of trainee participation compared to X-ray (15.3% (12,572/82,228) and 16.4% (12,213/74,330) respectively vs X-ray at 29.8% (66,805/223,855); P <0.001). The diagnostic imaging modalities with the highest percentage of trainee involvement were MRI (60.9%, 38,591/63,368) and CT (67.0%, 76,136/113,650) vs X-ray at 29.8%(66,850/223,855); P <0.0001. The majority of interventional studies also involved a trainee (eg, trainees were involved in 75% [11,041/14,765] of angiographic and gastrointestinal/genitourinary fluoroscopic studies).

Similar variation in trainee involvement was observed across subspecialty divisions. Trainee involvement ranged from 7.1% (3,657/51,841) in the ultrasound division to 99.2% (5,401/5,443) in the CID, P < 0.0001 for the difference (Fig 3). Trainee participation was 50% or

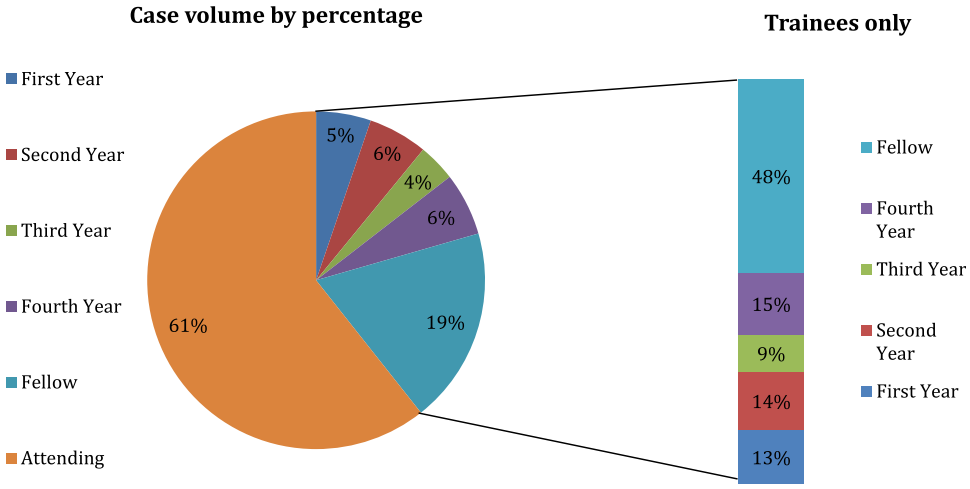

FIG 1. Trainee case volume.

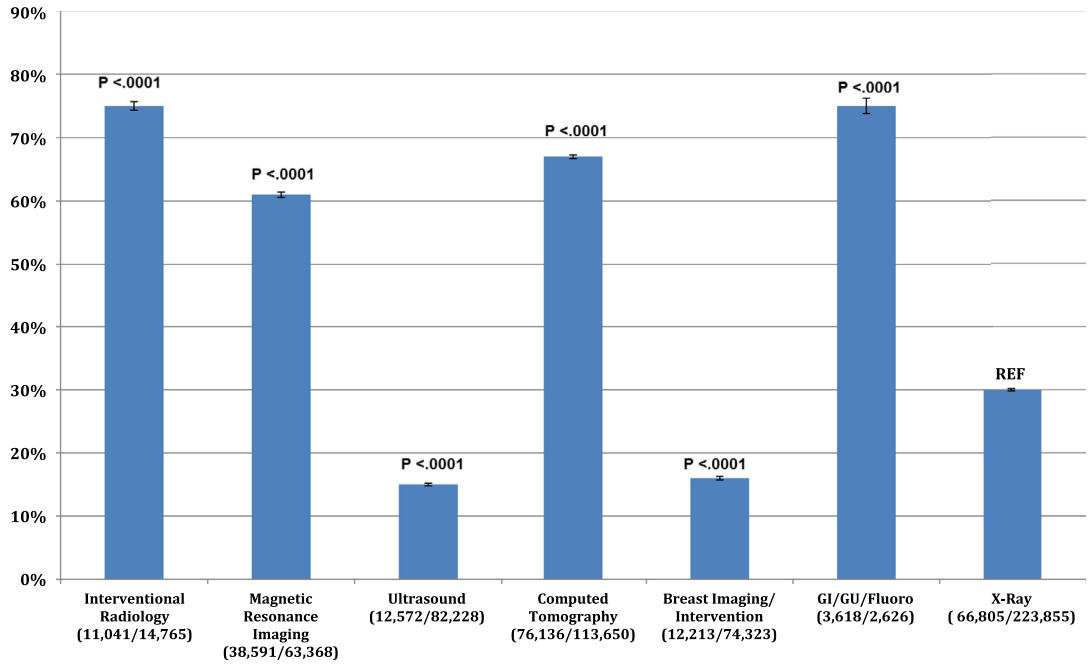

FIG 2. Trainee participation by modality. The number of studies with trainee involvement is included in the parenthesis below each modality. *P* values above each category reflect pairwise comparison between given category and the reference category.

lower for the thoracic, breast, musculoskeletal, neuroradiology, and ultrasound divisions. resident and fellow participation was greater than 50% for the abdominal, angiography and interventional radiology, cardiovascular, oncology, emergency, and nuclear medicine divisions.

Significant differences were also present in trainee involvement based on patient care setting. Residents and fellows were more likely to be involved in studies performed on inpatients (43.9%, 48,762/110,704) and patients in the ED (58.0%, 53,753/92,678), while only 33.9% (136,385/401,133)of outpatient studies involved a resident or fellow, $P < 0.0001$ vs inpatient and ED (Fig 4).

Discussion

In an academic radiology department at a major tertiary care hospital, residents and fellows participated in less than half of the imaging studies (diagnostic and interventional procedures combined). By

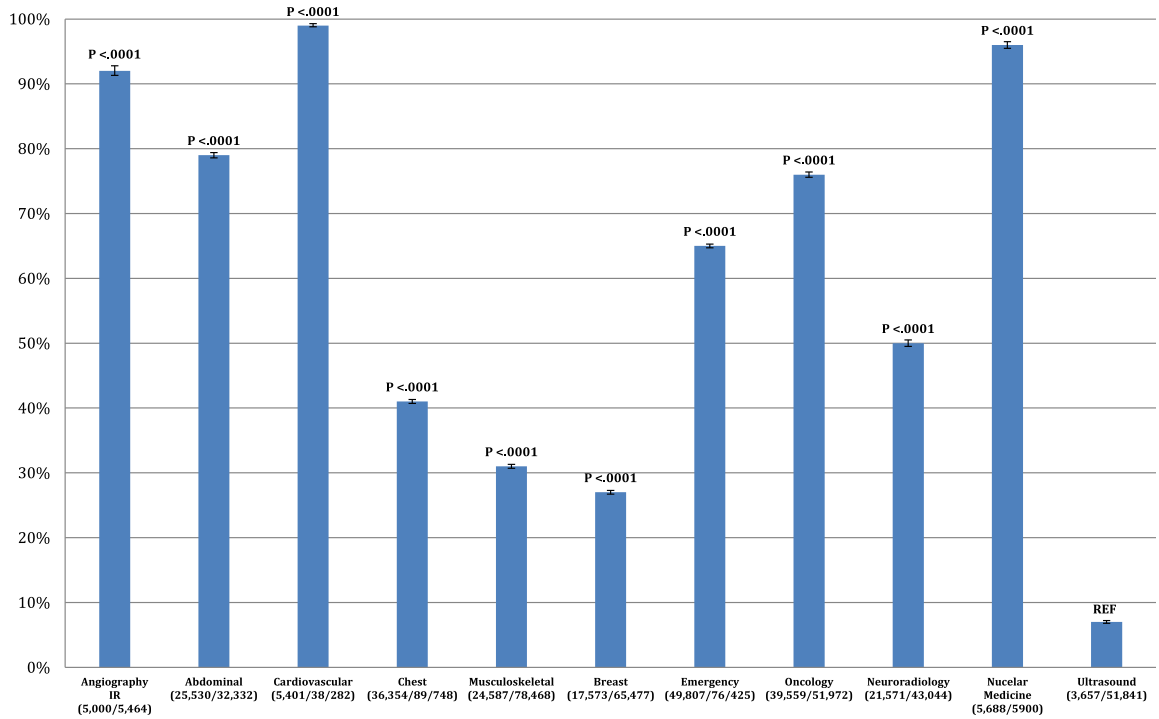

FIG 3. Trainee participation by division. The number of studies with trainee involvement is included in the parenthesis below each division. *P* values above each category reflect pairwise comparison between given category and the reference category.

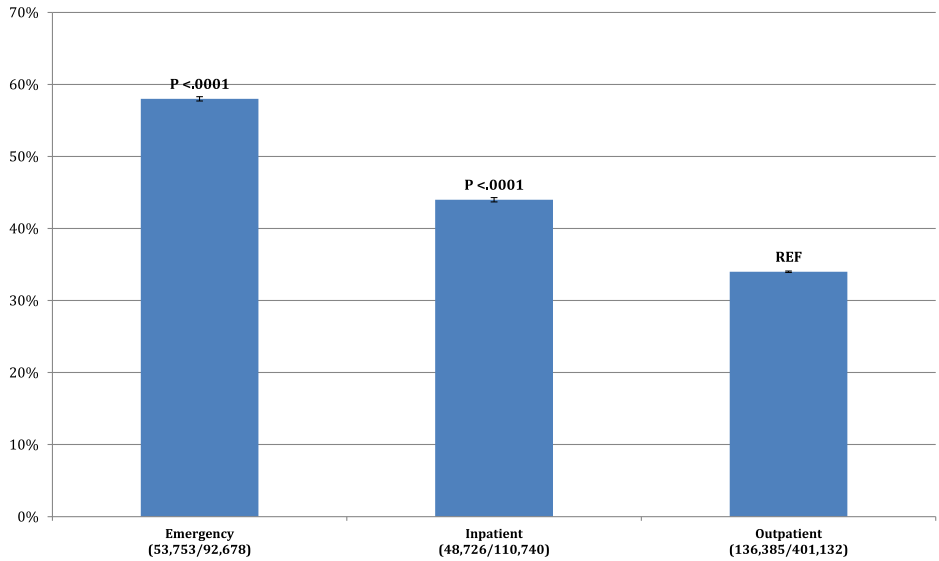

FIG 4. Trainee participation by patient setting. The number of studies with trainee involvement is included in the parenthesis below each patient care setting. *P* values above each category reflect pairwise comparison between given category and the reference category.

imaging modality, the proportion of trainee participation was lowest in radiographs, ultrasound, and mammography and highest in CT and MRI. By imaging subspecialty division, the ultrasound, breast, musculoskeletal, and thoracic divisions had the lowest trainee participation, with less than half of the reports involving trainees. In contrast, trainees were involved in more than 95% of the studies performed in the angiography and interventional radiology, nuclear medicine, and CID. Trainees were also substantially more likely to be involved in imaging studies performed on ED patients and inpatients, compared to outpatients.

The lower participation of trainees in X-ray imaging is likely due to the overall high volume of radiographs performed at our institution. While trainees only read approximately 30% of X-rays, this still amounts to over 66,000 X-rays in an academic year. However, it may still be argued that trainee participation is relatively skewed toward more advanced imaging, such as CT and MRI. This is in agreement with prior work which used medicare claims data to show that diagnostic services provided by radiology trainees disproportionately favored CT and MRI.[3] Various studies have shown that discrepancy rates between residents and attending radiologists are higher with CT and MRI, thus greater trainee involvement in advanced diagnostic imaging is likely necessary.[2,16]

Lower trainee participation in the interpretation of radiographs may also help explain the overall lower trainee involvement in the musculoskeletal and thoracic divisions. During the 2015 academic year, these subspecialty divisions read a disproportionately larger amount of radiographs compared to other divisions, greater than 127,000 X-rays in total. As trainees disproportionately read more read CTs and MRIs, attending radiologists interpreted most radiographs without trainees, resulting in lower trainee involvement in divisions with higher X-ray imaging volume.

Lower trainee participation in the ultrasound and breast imaging divisions may in part be explained by our institution's residency curriculum and the role of the trainee in patient care within each division. In the ultrasound division, trainees are expected to develop their technical skills by scanning each patient and present their findings to the attending physician. As a result of this emphasis on the acquisition of technical ultrasonography skills, trainees see fewer cases. Similarly, residents in the breast imaging division are often placed on the diagnostic imaging service that manages patients who either have an abnormality on a screening mammogram or physical exam. More time is spent with each patient and there is extensive direct patient physician interaction, resulting in fewer cases read in a given day. While residents also read screening mammograms, the majority of screening mammograms are read by attending physicians. The expectation to participate in direct patient care and the development of technical ultrasound skills, skills essential to the practice of radiology, may explain why trainees contribute to the minority of radiology reports in these divisions.

Higher trainee participation in certain divisions may be explained by a variety of factors. Divisions with higher CT and MRI volume, namely abdominal imaging and cardiovascular imaging, have higher trainee participation. At our institution, these 2 divisions also have a higher number of trainees. The CID has the largest number of fellows compared to other divisions and residents spend almost twice as much time in the abdominal division in our curriculum due to the need to cover both the gastrointestinal and genitourinary systems. The increased number of trainees likely plays a role in overall increased trainee participation in these radiology studies. Similarly, a high trainee to attending ratio may in part explain high trainee involvement in the ED. Residents and fellows are more likely to be involved in the care of ED patients and inpatients due to the inclusion of on call shifts during training, while most attending radiologists outside of the ED work during typical daytime hours (eg , 8AM-6PM) when most outpatients are imaged. Similarly, a relatively higher ratio of trainee to case volume may also explain increased resident and fellow participation in angiography and interventional radiology and nuclear medicine. With lower exam volume in these divisions, there is a higher likelihood of having a trainee available to help perform or interpret each exam.

While it may seem that academic radiology departments should maximize trainee participation, departments must balance variations in imaging volume with trainee educational requirements. For instance, while one could argue that residents at our institution should be reading more radiographs given the number of radiographs we perform, time spent on rotations with high radiographic volume must be balanced with all other modalities such as ultrasound, CT or MRI. Our residents also spend approximately 2 hours each day attending teaching conferences as part of the residency program. Fellows also attend structured didactic lectures and multidisciplinary conferences as part of their training. These lectures and conferences are invaluable for education, but have the potential to decrease trainee case volume. Nevertheless, in order to train well rounded radiologists, the trainee curriculum cannot be based on an institution's imaging volume alone, but also on academic and curricular

guidelines,[17,18] and thus imbalances in trainee participation and imaging volume will invariably exist.

In addition to fulfilling ACGME program requirements, analyzing trainee participation and imaging volume is another potential program evaluation tool for medical educators in radiology. Areas with low trainee participation should be analyzed to determine if this is due to high overall imaging volume, highly complex cases requiring more time per case, or additional time spent on direct patient care or technical training. Divisions with high trainee participation should ensure that there is adequate case volume per trainee and that there is not an oversaturation of trainees. Training programs may wish to establish expectations regarding the speed and participation of trainees in various divisions and modalities, with the goal of senior residents being able to more closely match attending radiologists in efficiency. Trainee participation analyzed over time and across the nation could also be used to help determine if there are enough positions for residents and fellows within single institutions and in the specialty of radiology as a whole.

Our study has several limitations that may reduce the generalizability of our findings. First, it was performed in a large, academic tertiary care medical center in an urban setting, which includes both a diagnostic radiology residency and several subspecialty fellowship programs. Our findings may not apply to smaller academic medical centers or residency programs and future work should be conducted in these settings. However, our data and methods can be used as a starting point for other departments to analyze their trainee participation to identify areas of strength and areas for potential improvement. Comparing individual institution data to one of the largest academic radiology departments in the country may serve as a helpful benchmark. Additionally, we did not adjust for the ratio of faculty to trainee staffing in each division or adjust for the number fellows in each division. This was mainly due to the inconsistent number of faculty and trainees in each division. Some faculties are members of multiple divisions, while others work part time. Some divisions do not have dedicated fellowship programs, and instead have rotating subspecialty fellows from other divisions, as is the case with our ultrasound division. Additionally, the role of each trainee may not be completely captured by their co-signature on a final radiology report, our primary metric in this study. Beyond interpretation of imaging studies, our trainees spend time in clinical consultation via phone calls and referring physician interactions, protocolling studies, monitoring sedation cases and contrast coverage, and interacting with patients and technical staff, all of which represent a significant amount of trainee time which is not measured in our study. Finally, we did not survey residents to determine how they felt about their educational experience and their satisfaction with their training, which could help guide future work.

In summary, while residents and fellows form an integral part of the care team in an academic radiology department, radiology trainees read the minority of imaging studies performed. While interpreting imaging studies does not constitute the full work of a trainee, trainees are involved in less than half of the imaging studies performed at a major academic radiology department. Trainee participation varies significantly by subspecialty division, imaging modality, and patient care setting. Assessing trainee participation by division and modality can help radiology educators assess potential areas of strengths and weakness in their department. Similar data and studies at other institutions may be useful to help define, monitor and improve optimal trainee educational and clinical experience nationally.

Supplementary materials

Supplementary data associated with this article can be found in the online version at doi:10.1067/j.cpradiol.2018.07.004.

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