Gender Bias in Diagnostic Radiology Resident Selection, Does it Exist?

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Rationale and Objectives: To investigate whether there is a bias in the residency selection process that influences the proportion of females entering diagnostic radiology residencies.

Materials and Methods: A total of 4117 applications to one diagnostic radiology residency program from 2008 to 2014 were analyzed. Invitations to interview were evaluated by each year, specifically looking at gender. Ranking of applicants, especially those placed in top 25% of the rank, was also assessed. Additional data analyzed included United States Medical Licensing Examination Step 1 board examination score (a proxy for academic performance), interview scores, and final position on rank list.

Results: Female applicants averaged 24% of the total applicant pool during the years studied, yet made up a disproportionately high percentage of applicants invited to interview (30%) and those ranked in top 25% (38%). It was found that female applicants had slightly higher mean interview scores and lower Step 1 scores than male applicants.

Conclusions: Our findings suggest that program directors in one program want to increase gender diversity by making strides to keep the female candidate pool and the proportion of female residents in the program at least stable. The pipeline of female medical students pursuing a career in radiology appears to be a limiting factor rather than a bias against women in the resident selection process. Identifying such trends is important as it provides a better understanding of the etiology for an overall lack of gender diversity within the field. Furthermore, it may lead to closing the gender gap in radiology.

Key Words: Education; Gender; Bias; Diversity; Radiology; Women; Resident.

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INTRODUCTION

Although the percentage of women graduating from medical schools in the United States has increased significantly in the last few decades, reaching almost 50% in 2007, there has not been a parallel increase in gender composition of medical graduates pursuing diagnostic radiology residency programs (1). The proportion of women starting a career in radiology has remained remarkably stagnant since at least 1980, when 25.5% of all radiology residents were female (2). As of 2013, women made up just 26.8% of all the radiology residents, demonstrating only a 1.3% increase in more than 30 years (3). Conversely, the gender landscape in other specialties has changed significantly during this same period of time. In the 1980s and prior, female residents were concentrated in internal medicine, obstetrics and gynecology, pediatrics, and family medicine (4). Since then, women have redistributed throughout most other specialties, even those that are historically male predominant such as surgery and the various surgical subspecialties (3,4). Radiology has not benefitted from this redistribution of women in medicine, as evidenced by the fact that the proportion of women in the specialty has not significantly changed.

The reason women continue to be underrepresented in radiology has been studied at length, including baseline interest of medical students in radiology, factors influencing interest, and whether these factors differ between genders (5,6). Lifestyle factors and other characteristics that influence whether medical students choose radiology as a career, such as the amount of patient contact, salary, and competitiveness, have also been described in relationship to gender (7). The influence of female role models, program directors, and faculty in determining a female medical student’s career path has also been investigated in several articles (5,8,9).

Diversity is celebrated as an important factor contributing to the success of companies and businesses. Increased diversity has been shown to correlate with increased sales revenue, greater market share, and higher profits (10). Large, successful companies recognize this and many make pointed efforts to enhance diversity within the workforce (10). A successful group, whether it be a business or a radiology residency training program, needs to be able to recruit and hold on to the most talented individuals available. This is not possible if almost half of the candidate pool (female medical students) is not even considering a career in radiology. There are also reasons more specific to the field of radiology. There have been shortages of mammographers and pediatric radiologists in recent years (11–14). It has been found that female radiologists are much more likely to pursue a career in these two subspecialties than

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males, and increasing the pool of female radiologists could lead to ending this shortage (11–14).

The presence of gender bias in academia and science is a current topic of interest. Despite an increasingly integrated workforce and education environment between men and women, many studies suggest that gender bias may persist in these communities (15). For example, a recent study demonstrated that unconscious bias favoring men exists in science faculty members’ perception of students (16). As a testament to the potential significance of this finding, it has been shown that a small degree of bias in the assessment of job applicant performance correlates to large differences in the number of positions filled by different types of applicants (17). Despite the awareness of gender bias in scientific communities and the ongoing discussion about the lack of gender diversity in diagnostic radiology in the literature, a study has not been undertaken to discern if there is gender bias at the level of resident selection in United States radiology programs. Because women are not entering radiology residencies in a similar proportion to other specialties (3), we hypothesize that gender bias occurs at the level of radiology resident selection.

**METHODS**

This study is a retrospective cohort study investigating a total of 4117 applications to one diagnostic radiology residency program from 2008 to 2014. Data from these applications were obtained from the Electronic Residency Application Services (ERAS). All applications were analyzed anonymously to protect applicant privacy. The residency program of study is a large-sized, university program with a total of 36 residents and is located in the Southeast.

Data extracted from all applications included gender, United States Medical Licensing Examination (USMLE) Step 1 score, medical school type (international versus noninternational), and whether the applicant was invited to interview. USMLE Step 1 score was chosen as a proxy for overall academic performance as it has been shown to directly correlate with academic performance and because other metrics such as the number of honors/passes/fails or Alpha Omega Alpha status differ by medical school (18).

Additional data extracted from the applications of individuals invited to interview included mean interview score, whether the applicant was ranked, and final position on the rank list. Finally, to determine the consequence of any possible gender bias, the final match status of the applicants ranked was also investigated.

At our institution, all applications are initially reviewed by two members of the selection committee, the Program Director and the Assistant Program Director. Applicants are invited to interview based on grades in clinical clerkships, Medical Student Performance Evaluations (MSPEs), leadership experience, USMLE step 1 score, volunteer work, research, letters of recommendation, and significant life experiences.

The proportion of females to total applicants at the stages of invitation to interview, rank, rank in the top quartile, and match was determined for each year. Trends in these proportions over the years studied were analyzed using slopes tests. Threshold for statistical significance was set at \( P < 0.05 \) for all analyses. Slopes test was also used to analyze the trend in the proportion of total female applicants over the years studied.

We compared our local data to national data using a one-sample binomial test to assess whether our findings are mirrored on a larger scale. National data were obtained from publicly available ERAS data, which report applicant number by gender for all programs accredited by the Accreditation Council for Graduate Medical Education (19). The only ERAS years available for comparison were 2010–2014, and these are the only national data currently available that divide residency applicants by gender and by specialty. ERAS data are permissible to be reproduced and distributed with attribution for educational noncommercial purposes. We also compared trends in the proportion of female applicants to this radiology program with the proportion of female applicants to radiology programs nationwide utilizing the same ERAS data over time using a slopes test. A slopes test was also used to determine if there was a significant trend in the proportion of the females out of the total applicant pool nationwide over the years studied.

Lastly, a slopes test was used for both national and local data to determine trends in the total number of applicants to programs for years 2010–2014 and years 2008–2014, respectively.

For each year individually, we compared the observed proportion of women invited to interview to the hypothesized proportion that would be expected to be invited to interview if the proportion of total female applicants was maintained with a one-sample binomial test. We also used a one-sample binomial test to compare the percentage of women ranked in the top 25% of the rank list to the hypothesized percentage that would be expected to be ranked in the top 25% if the proportion of female applicants invited to interview was maintained with a one-sample binomial test.

USMLE Step 1 score and mean interview score for each year separated by gender was also compared to determine whether differences in females from males at various stages in the match process is due to differences in qualifications (academic performance, interview performance) between genders or due to bias related to the applicant’s gender. Mean interview score refers to the average of all scores an applicant received from each interviewer. The average of all male and female applicants’ Step 1 scores and mean interview score was used for each year. Statistical significance \((P < 0.05)\) for the difference between male and female mean interview scores and USMLE Step 1 scores was determined using Welch’s unpaired t tests and also analysis of variance (ANOVA) tests. Post hoc comparisons were conducted using the Sidak method of correcting for multiple comparisons.

**RESULTS**

Female applicants made up an average of only 24% \((N = 993/4117)\) of the total applicant pool during the years 2008–2014 (Table 1). However, females comprised 30%
(N = 250/837) of all the applicants invited to interview, as well as 30% (N = 176/594) of those ranked and 38% (N = 55/145) of those ranked in the top quartile (Table 1). Therefore, although only 24% of the applicant pool was female, women made up a significantly increased proportion of the applicants invited to interview (30%) (P < 0.001). Similarly, females made up a disproportionate number of the applicants ranked in the top 25% of the rank list (38%) when compared to the 30% of female applicants invited to interview. This difference is statistically significant (P < 0.001). Over the years studied, women made up 25% of the individuals that matched into this program.

There was no significant observable trend over time in the proportion of the various groups that was female. Meaning, the proportion of female applicants relative to the total number of applicants invited to interview (P = 0.71), ranked (P = 0.09), or ranked in top quartile (P = 0.88) did not change significantly over the years studied, 2008–2014 (Fig 1).

The number of female applicants per year ranged from 116 to 175, peaking in 2010 and lowest in 2014. The number of male applicants per year ranged from 409 to 485. Volume of male applicants also peaked in 2010, but was the lowest in 2012 and in 2013. The proportion of female applicants to total applicants has decreased at this institution over the last 7 years, but not to a significant degree (P = 0.54). National data mirror local data in the decreasing proportion of female applicants to total applicants, although not to a significant degree (P = 0.13) (19). Similarly, our local data were congruent with national ERAS data in that the percentage of women in the total applicant pool has trended down in the years 2010–2014 approximately the same degree in both populations, the slopes are not significantly different (P = 0.72). Finally, comparing our local institution data to national ERAS data for the years 2010–2014 (Table 2), we found that the proportion of women who applied to the program in our study is smaller (P < 0.001) (19).

Female applicants had consistently lower USMLE Step 1 scores than male applicants, ranging from a difference of 2 to 8 points during the years studied, with an average of 5 points’ difference (Fig 2). In 5 out of the 7 years studied, this discrepancy between male and female applicant Step 1 scores was found to be statistically significant (P < 0.05) (Fig 2). In addition, ANOVA test discovered a significant main effect of sex, indicating that men had higher scores than women (P < 0.001).

### Table 1. Distribution of Female Applicants as Percentage of Total Applicant Pool, Applicants Invited to Interview, Applicants Ranked, and Applicants Ranked in Top Quartile, 2008–2014

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>All applicants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>144</td>
<td>152</td>
<td>175</td>
<td>140</td>
<td>144</td>
<td>122</td>
<td>116</td>
<td>142</td>
</tr>
<tr>
<td>Male</td>
<td>480</td>
<td>483</td>
<td>485</td>
<td>441</td>
<td>409</td>
<td>409</td>
<td>417</td>
<td>446</td>
</tr>
<tr>
<td>% Female of total</td>
<td>23.1%</td>
<td>23.9%</td>
<td>26.5%</td>
<td>24.1%</td>
<td>26.0%</td>
<td>23.0%</td>
<td>21.8%</td>
<td>24.1%</td>
</tr>
<tr>
<td>Invited to interview</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>38</td>
<td>31</td>
<td>34</td>
<td>38</td>
<td>35</td>
<td>33</td>
<td>41</td>
<td>36</td>
</tr>
<tr>
<td>Male</td>
<td>92</td>
<td>73</td>
<td>78</td>
<td>74</td>
<td>72</td>
<td>102</td>
<td>96</td>
<td>84</td>
</tr>
<tr>
<td>% Female of total</td>
<td>29.2%</td>
<td>29.8%</td>
<td>30.4%</td>
<td>33.9%</td>
<td>32.7%</td>
<td>24.4%</td>
<td>29.9%</td>
<td>30.1%</td>
</tr>
<tr>
<td>Ranked</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>32</td>
<td>26</td>
<td>23</td>
<td>23</td>
<td>22</td>
<td>21</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>Male</td>
<td>68</td>
<td>45</td>
<td>57</td>
<td>56</td>
<td>54</td>
<td>69</td>
<td>71</td>
<td>60</td>
</tr>
<tr>
<td>% Female of total</td>
<td>32.0%</td>
<td>36.6%</td>
<td>28.8%</td>
<td>29.1%</td>
<td>28.9%</td>
<td>23.3%</td>
<td>29.0%</td>
<td>29.7%</td>
</tr>
<tr>
<td>Ranked in top 25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>10</td>
<td>7</td>
<td>7</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
<td>11</td>
<td>14</td>
<td>10</td>
<td>12</td>
<td>16</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>% Female of total</td>
<td>36.8%</td>
<td>38.9%</td>
<td>30.0%</td>
<td>50.0%</td>
<td>36.8%</td>
<td>30.0%</td>
<td>42.3%</td>
<td>37.8%</td>
</tr>
</tbody>
</table>

**Figure 1.** Percentage of total applicants, applicants invited to interview, applicants ranked, and applicants ranked in the top quartile who were female, 2008–2014. (Color version of figure available online).
Conversely, female applicants invited to interview had higher mean interview scores than male applicants invited to inter-
view in 6 out of the 7 years, by an average of 3.1 percentage
points (Fig 3). In 3 out of the 7 years studied, this discrep-
ancy between male and female interview scores was statistically
significant ($P < 0.05$) (Fig 3). ANOVA test revealed a signif-
icant main effect of sex, indicating that women had higher
mean interview scores than men ($P = 0.03$).

**DISCUSSION**

The proportion of female applicants to this program has been
trending down, although not to a statistically significant degree.

The number of female applicants to our program has re-
mained stagnant, following suit of the national trends.

The proportion of female applicants to this program is con-
sistently and significantly lower than observed in national ERAS
data. Historically, the Northeast has a larger female radiolo-
gist population than the South (20). Also, it has been shown
that 52.8% of female radiologists go on to practice in the same
state that they attended residency (21). Therefore, it can be
theorized that perhaps fewer females apply and attend radi-
ology residencies in the South as a whole, and the number of female applicants to our program is in proportion to the
rest of the region. This suggests that regional differences in
perception of gender roles for medical specialties could have

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**TABLE 2. National ERAS Data: Number of Applicants to ACGME Radiology Residency Programs per Year by Gender**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>No answer</th>
<th>% Female of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>2322</td>
<td>712</td>
<td>1607</td>
<td>3310</td>
<td>30.7%</td>
</tr>
<tr>
<td>2011</td>
<td>2592</td>
<td>830</td>
<td>1759</td>
<td>22</td>
<td>32.1%</td>
</tr>
<tr>
<td>2012</td>
<td>2637</td>
<td>780</td>
<td>1856</td>
<td>0</td>
<td>29.6%</td>
</tr>
<tr>
<td>2013</td>
<td>2780</td>
<td>826</td>
<td>1954</td>
<td>2</td>
<td>29.7%</td>
</tr>
<tr>
<td>2014</td>
<td>2632</td>
<td>758</td>
<td>1872</td>
<td>2</td>
<td>28.8%</td>
</tr>
<tr>
<td>2015</td>
<td>2592</td>
<td>781</td>
<td>1810</td>
<td>2</td>
<td>30.2%</td>
</tr>
</tbody>
</table>

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**Figure 2.** Mean United States Medical Li-
censing Examination (USMLE) Step 1 score
per year by gender, 2008–2014. (Color
version of figure available online).

**Figure 3.** Mean interview scores per year
by gender, years 2008–2014. (Color version
of figure available online).
an effect on the distribution of female applicants to radiology residencies.

In the absence of gender bias or in the presence of a significant discrepancy between genders in a major applicant selection criterion (academic performance, letters of recommendation, etc.), one would expect approximately equal proportions of men and women in the total applicant pool as in the invited to interview pool. However, this was not the case observed in our study. Females represented a significantly higher percentage of the invited to interview group than of the group of total applicants (30% versus 24%). The increased percentage of women cannot be explained by superior academic performance, as men had higher USMLE Step 1 scores in this population. It is important to note that although the average Step 1 score overall was higher in male than in female applicants in the applicants invited to interview, the same minimum score was observed for both genders.

The disproportionate number of women invited to interview is also unlikely to be attributable to more convincing letters of recommendation. Although it has been found that men and women are described differently by faculty in medicine and science, these differences are unlikely to favor females. Letters of recommendation for women are shorter and more frequently contain “doubt-raising” language, whereas those for men tend to be longer and contain more “standout” adjectives (22,23). It has also been illustrated that women are more frequently described in communal terms (i.e. nurturing, kind) whereas men are described as agentic (i.e. ambitious, confident) (24). These are important descriptive distinctions in that the latter are more positively correlated with hireability and attaining positions of leadership (24).

Although we did not investigate the content of applicants’ letters of recommendation during this study, based on data from prior studies, it would seem that letters of recommendation would, if anything, decrease female applicants’ chances of being invited to interview. In addition, letters of recommendation are not consistently cited by program directors as being one of the more important aspects in selecting applicants to interview, making this variable even less likely to be the source of a significant difference between the proportions of men and women invited to interview (25).

Conversely, MSPEs have been mentioned as an important factor in selecting applicants for interviews in several years of National Residency Match Program survey of radiology program directors (25). Again, although we did not investigate the MSPEs of applicants during this study, the topic has been previously investigated. One article found interesting differences attributable to the gender of the authors of MSPEs and the students they are written for (26). However, the article did not find any correlation with these differences and the likelihood of applicants being ranked (26). Therefore, it does not seem likely that differences in MSPEs between genders could explain the disproportionately high number of women invited to interview at this program.

The type of medical school from which the applicants came from is also unlikely to explain our findings. Medical student graduates from international medical schools are less likely to match successfully across specialties in the United States for reasons that have been hypothesized by others (27–30). In our study a congruent pattern was observed in that international medical school graduates (IMGs) were less likely to be invited to interview than non-IMGs. The only significance of the type of medical school that applicants were from in terms of gender is that there are more IMG applicants that are female than non-IMGs that are female applying to this program and to radiology programs nationwide (31). Therefore, if IMGs were not considered, the applicant pool would be only 23% female, rather than 24%, making the 30% invited to interview even more striking.

In the group of applicants ranked in the top quartile of the rank list, the proportion of females (38%) is also higher than would be expected without any gender bias or other significant difference in selection criteria for ranking applicants between sexes. In terms of criteria that are significant for an applicant to be ranked, the interview process must be considered. Women had, on average, higher interview scores during the years studied than men. Because interview performance is consistently identified as the most important factor in selecting applicants to rank, it is plausible that the higher interview scores can in part explain the disproportionately high number of women that were ranked highly (25).

At our institution, interviews are conducted in a semistructured interview style. All interviewers share a menu of questions designed to elicit similar data from each candidate. The purpose of using this method is to obtain valid and reliable information while maintaining consistency. This method requires the selection committee to commit to certain evaluation criteria before seeing applicants, which is an evidence-based method of decreasing practices that facilitate the application of biases (15). Applicants are interviewed by three faculty members for 20 minutes each. Each faculty member scores the applicant on a 20-point scale based on patient care, medical knowledge, practice-based learning, communication/interpersonal skills, and professionalism, up to 4 points for each category. The gender profile of the selection committee during the years studied was made up of, on average, eight males and six females. It is worth noting that the Program Director and the Assistant Program Director positions were held by females for the duration of the years studied. Applicants are ranked using a cumulative score of their application review and interview score.

Of the residents who ended up matching into this program in each year studied, women made up an average of 25% of the entering class. This is slightly lower than the national percentage, 26.8%, which may partially be attributed to the same factors discussed earlier relating to geographical location (3).

The number of females invited to interview and ranked in the top 25% is greater than would be expected in the absence of some type of gender bias. Given that no other major factors that are typically deemed highly important in selecting applicants to interview or to ranking are evidently different between genders in a way that would benefit women, it seems
possible that this apparent advantage is representative of a form of gender bias toward females. It is unclear if this proposed bias is conscious or unconscious. Regardless of the etiology, possible bias in favor of female medical students is helping to maintain the number of women at this program around 25%, the same percentage that female radiology residents nationwide have been hovering around for decades (3).

This finding is significant as it implies that the most likely source for the gender gap in radiology is the pipeline of female medical students interested in a career in radiology, rather than discrimination. Previous studies have proposed several potential reasons female medical students do not choose to go into radiology. One study examined whether medical students’ ideas about various factors related to specialty choice differed by gender, yet concluded that there was no significant difference between sexes (7). However, another similar study demonstrated that male and female attitudes about the amount of patient contact and the technology focus of radiology differed (5). The amount of patient contact was more positively correlated with specialty choice in female medical students than male, whereas significant technology focus was more negatively correlated (5). These findings are interesting because there are other specialties such as pathology, which have very little direct patient care, less so than radiology, yet have much higher numbers of female medical students entering residencies (3).

The importance of diversity in academic medicine has been realized and discussed recently, and various organizations have spoken to the responsibility that leaders have to help enhance it (11). For example, an Association of American Medical Colleges sponsored seminar instructed the academic medical community to “work hard to ensure that women comprise at least 25% of the candidate pool” (15). Maintaining a certain level of diversity is important because it may prevent the perpetuation of gender bias. A systematic review reported that the proportion of women to men in the applicant pool affects the level of bias that occurs during the hiring process. The study further states that a proportion of greater than 25% of women reduces bias, a potentially particularly significant factor in radiology because women currently make up close to 25% of radiology applicants, residents, and faculty (32,33).

Several articles in surgical literature, a field in which the proportion of women has been rapidly increasing in recent years, have discussed the importance of residents in influencing female medical students’ decisions about specialty choice.

One study investigated the relationship between specialization of medical students in the United States and the sex of their faculty, department chairs, and residents in the programs they enrolled (8). This study found no significant associations between exposure to potential role models or female faculty and specialty choice, but did observe that female students were more likely than male students to enter programs with higher proportions of residents of the same gender entering that program in the year prior (8). In another study, Pelletier and Belliveau suggest that medical students pursuing a career in surgery deem residents to be even more important than attending physicians in their education (34). Female resident involvement in medical student education has been one of the successful methods in which gender diversity has been increased in surgery residencies (35).

Lastly, it has been shown that increasing the exposure medical students have to radiology increases their interest in the field (6). Therefore, having excellent female radiology residents visible and involved in education of medical students has potential to encourage students to pursue specialization in radiology. Perhaps having female radiology residents lead seminars or give lectures to medical students would be a tactic to increase gender diversity in the field. As of 2011, this method of encouraging students to choose radiology as a career had not been enthusiastically adopted. In a survey of program directors at that time, it was found that “most radiology programs do not have residents-as-teachers programs, nor do they plan to initiate them” (36). Female residents teaching and mentoring medical students is possibly an important future direction to enhance diversity, and it is impossible to implement this method without enough female radiology residents to do so.

This study has some limitations. The inherent multifactorial nature of the resident selection process will always remain a barrier. There are no universal selection criteria for the selection of candidates to interview or rank. Likewise, there is no universal scoring method common between programs. Therefore, it cannot be predicted how our findings will compare to other institutions. These limitations present an opportunity to expand this pilot project to include other institutions. We also plan to conduct a survey of program directors to elucidate information about the presence of bias at other institutions, possible causes of gender bias, demographic data, interviewing techniques, perceptions about the pipeline of female medical students, perception of male versus female resident performance, and if/how residents as teacher programs are being utilized. An additional project we plan to undertake will evaluate the factors contributing to the plateaued pipeline of female students entering radiology.

CONCLUSION

Our data represent valuable information from one program and is perhaps the first concrete suggestion in the literature that gender bias exists in the selection of radiology residents. Our findings imply that regardless of bias, it may be difficult to increase diversity in the field with a stagnant to decreasing number of female applicants. Leaders in radiology can learn from the success other specialties have experienced in increasing gender diversity. Further investigations including data from additional programs and possible reasons for the bias will provide a better understanding of the etiology for an overall lack of diversity within the field.

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