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Retrospective Analysis of Gender Disparity in Radiology Subspecialty Training: A Decade of Little Progress

Dennis Parhar[1,2,3] · **Faisal Khosa**[1,3]

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Abstract
Introduction A number of initiatives have been introduced to address the issue of gender disparity within radiology. It remains to be seen whether these endeavors have resulted in any significant improvement, particularly within the subspecialties of radiology. We aimed to assess the trends in gender distribution of radiology subspecialty training programs over the past decade.
Methods Retrospective analysis of publicly available demographic data, from the Journal of the American Medical Association publications, of trainees in accredited training programs in the United States from 2008/09 to 2018/19. The proportion of female trainees across the last decade were compared using Pearson's chi-square test and the Cochran–Armitage trend test.
Results Among 399 accredited radiology subspecialty training programs, encompassing 882 subspecialty trainees, females accounted for 23.1% of trainees. There has been a downward trend in the proportion of female trainees over the past decade ($p = 0.0027$). Among the subspecialties, the disparity was largest within interventional radiology training programs (15.7% female) and was lowest in pediatric radiology (44.2% female). Interventional radiology was the only subspecialty demonstrating an upward trend during this period ($p = 0.0050$).
Discussion Despite remedial actions, there has been a downward trend in the proportion of female subspecialty trainees over the past decade. This ongoing disparity puts radiology at risk of falling behind other specialties in realizing the benefits and growth of having physician representation. Among other endeavors, an increased focus on the pipeline of trainees, starting in medical school, has proven effective for some radiology subspecialties, and merits further attention.

Keywords Training · Fellowship · Subspecialty · Gender · Disparity · Female · Radiology

Introduction

Access to diverse groups of physicians is associated with better patient health outcomes and patient satisfaction, as well as improved morale within physician groups and reduced physician burnout [1]. Indeed, promoting diversity in the physician workforce is established as a key strategy in reducing health disparity [2]. While significant progress has been made toward equity, diversity, and inclusion in the physician workforce, females still comprise only an approximate one-third of the physician workforce [3]. Female physicians also face additional challenges, including a lack of role models, gender bias and discrimination, and the need for better work–life integration [•4, 5–7].

Currently, the diversity of patients is not reflected in the physician workforce and this discrepancy is expected to widen as the population of the United States (US) continues to diversify [••8]. The discrepancy is of particular concern in diagnostic and interventional radiology, which

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✉ Faisal Khosa
fkhosa@hotmail.com

[1] Department of Radiology, The University of British Columbia, Vancouver, Canada

[2] T.H. Chan School of Public Health, Harvard University, Cambridge, USA

[3] Department of Radiology, Vancouver General Hospital, 899 12th Avenue W, Vancouver, BC V5Z 1M9, Canada

are traditionally male dominated specialties [9]. In 2014, females comprised only 22% of the practicing radiology workforce [10]. Similar results were found among the academic faculty in subspecialties of radiology, its professional societies, and editorial boards of its journals [11–13]. While female physicians represent at least half of the medical graduates in contemporary cohorts, they currently account for only 26.9% of diagnostic radiology residents, representing one of the largest discrepancies among the major specialties [14].

Previous studies have offered a number of approaches to reduce this disparity, including increasing mentorship opportunities, increasing visibility and accomplishments of under-represented groups, and programs that provide executive coaching and training experiences [2, 15, 16]. It remains to be seen whether these endeavors have resulted in any significant improvement. Our aim was to provide an updated look at the current status of gender disparity in radiology subspecialty training, and its trend over the past decade. We hypothesized that the gender disparity has not significantly changed over the past decade.

Methods

This study was conducted following the guidelines published in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [17]. Research ethics approval was waived as the study employed only publicly available, non-identifiable data.

Cohort Selection

The data regarding the number of trainees, their demographics, and background medical training were retrieved from annual graduate medical education surveys administered jointly by the American Medical Association (AMA) and the Association of American Medical Colleges (AAMC). Residency and fellowship directors of all ACGME (Accreditation Council of Graduate Medical Education) accredited program are asked to complete a census of their programs on an annual basis and results are published in the Journal of the American Medical Association [18–28]. The surveys have an average response rate of approximately 94% [29].

We compared the gender representation among all ACGME-accredited radiology subspecialties, including abdominal radiology, musculoskeletal radiology, neuroradiology, nuclear radiology, pediatric radiology, and vascular/interventional radiology, as well as the pipeline of diagnostic radiology residency programs. Since training pathways can differ for some subspecialties, data were combined for the following categories: radiology-based endovascular surgical neuroradiology programs were included within the neuroradiology subspecialty, nuclear medicine residency programs and combined nuclear medicine/diagnostic radiology residency programs were included with nuclear radiology subspecialty, and integrated interventional radiology residency programs were combined with vascular/interventional radiology fellowships. Other fellowships, such as clinical informatics, women's imaging, or breast imaging, had no ACGME-accredited programs in the review period; thus, no data were available. No accredited cardiothoracic radiology fellowship programs were reported after the 2010/11 academic year; thus, this subspecialty was also excluded.

Statistical Analysis

The 2008/09–2018/19 data files were merged and subsequent statistical analyses were performed in SAS 9.4 (SAS Institute, Inc., Cary, NC). Continuous data were analyzed using independent two-sided *t*-tests or Wilcoxon rank sum tests, depending on normality of the data, whereas categorical data were analyzed using Pearson's chi-square tests. Cochran–Armitage trend tests were performed to study the trends of gender distribution over time. All statistical testing was performed with a two-sided alpha level of 0.05 and/or 95% confidence interval (CI). The data were further analyzed for medical school of graduation, i.e., North America or international medical school graduates, using Pearson's chi-square test.

Results

There were 13 abdominal radiology, 16 musculoskeletal radiology, 89 neuroradiology, 59 nuclear radiology, 46 pediatric radiology, and 176 interventional radiology accredited training programs in the 2018/19 academic year. Of these programs (encompassing 882 trainees), females represented 23.1% of trainees ($n = 204$). Vascular/interventional radiology had the lowest proportion of female trainees (15.7%, $n = 70$) followed by musculoskeletal radiology (22.2% female, $n = 6$), neuroradiology (25.7% female, $n = 61$), and abdominal radiology (30.6%, $n = 11$). Pediatric radiology had the highest proportion of female trainees (44.2%, $n = 23$), followed by nuclear radiology (39.3%, $n = 33$). These results are summarized in Table 1.

There has a been a significant downward trend (Cochran–Armitage trend test, $p = 0.0027$) in the proportion of total female subspecialty trainees in the past decade (2008/09–2018/19), reaching a maximum of 27.1% in 2009/10 and a minimum of 20.1% in 2017/18 (Table 1; visually depicted in Fig. 1). Among the pipeline of diagnostic radiology residency programs, there has also been a

Table 1 Gender distribution of radiology trainees over the last decade (2008/09–2018/19)

ACGME Accredited Subspecialty	Academic Year										*p* value
	2008–2009 % female (*N*)	2009–2010 % female (*N*)	2010–2011 % female (*N*)	2011–2012 % female (*N*)	2012–2013 % female (*N*)	2013–2014 % female (*N*)	2014–2015 % female (*N*)	2015–2016 % female (*N*)	2016–2017 % female (*N*)	2017–2018 % female (*N*)	2018–2019 % female (*N*)	10 Year Trend
All subspecialties	23.0 (156)	27.1 (188)	27.5 (193)	24.1 (179)	24.9 (172)	24.9 (192)	22.5 (150)	21.3 (152)	22.7 (158)	20.1 (158)	23.1 (204)	**0.0027**
Abdominal	29.3 (12)	47.5 (19)	38.9 (14)	40.0 (6)	21.9 (7)	25.6 (10)	25.0 (10)	29.6 (8)	33.3 (12)	23.5 (8)	30.6 (11)	0.1317
Musculoskeletal	16.0 (4)	24.0 (6)	16.7 (4)	25.8 (8)	34.8 (8)	31.0 (9)	15.0 (3)	40.0 (8)	9.5 (2)	40.0 (8)	22.2 (6)	0.5053
Neuroradiology*	20.9 (53)	24.3 (62)	24.3 (58)	18.4 (47)	19.1 (45)	25.0 (69)	22.4 (49)	18.2 (45)	20.1 (50)	20.4 (54)	25.7 (61)	0.9349
Nuclear radiology†	34.6 (54)	38.8 (62)	39.4 (61)	40.2 (58)	33.3 (40)	35.3 (42)	26.8 (26)	35.4 (34)	31.7 (26)	32.9 (27)	39.3 (33)	0.3403
Pediatric radiology	37.5 (21)	42.6 (23)	50.7 (34)	48.0 (36)	49.4 (42)	47.1 (41)	46.0 (40)	44.3 (35)	43.3 (26)	29.2 (14)	44.2 (23)	0.4620
Vascular/interventional‡	8.1 (12)	10.1 (16)	12.2 (22)	10.9 (16)	15.4 (30)	9.5 (21)	10.8 (22)	9.3 (23)	16.9 (42)	13.9 (47)	15.7 (70)	**0.0050**
Diagnostic radiology residency	28.1 (1251)	28.0 (1257)	27.8 (1260)	27.8 (1259)	27.8 (1233)	27.2 (1218)	27.0 (1186)	26.7 (1190)	26.0 (1179)	26.2 (1179)	26.8 (1171)	**0.0018**

*Including Endovascular Surgical Neuroradiology

†Including Nuclear Medicine and Combined Programs

‡Including Interventional Radiology Residency

significant downward trend ($p = 0.0018$) in the past decade, reaching a maximum of 28.1% in 2008/09 and a minimum of 26.0% in 2016/17. The relative reduction over the decade was calculated using the mean proportion of the earliest 3 years of the study period (2008/09–2010/11) and the most recent 3 years of the study period (2016/17–2018/19). There was a 5.8% relative reduction in the residency cohort, while there was a 15.1% relative reduction among subspecialty trainees. No significant trend (positive or negative) was observed in the following subspecialties: abdominal radiology, musculoskeletal radiology, neuroradiology, nuclear radiology, and pediatric radiology (Table 1; visually depicted in Fig. 2). In vascular/interventional radiology, there has been a significant increase in the proportion of female trainees over the last 10 years ($p = 0.0018$), reaching a maximum of 16.9% in 2016/17 from a minimum of 8.1% in 2008/09.

A higher proportion of 2018/19 radiology subspecialty trainees were American or Canadian medical school graduates (USCMGs; 78.7%, $n = 700$) compared to international medical school graduates (IMGs; 21.3%, $n = 189$); results are summarized in Table 2. The gender disparity was significantly larger among the USCMG cohort than the IMG cohort: females represented 35.5% of the IMG cohort and 20.0% of the USCMG cohort ($p < 0.0001$). Within individual subspecialties, the gender disparity was also larger for USCMGs than for IMGs, except for interventional radiology (females represented 16.3% of USCMGs, and 11.1% of IMGs). Only neuroradiology demonstrated statistical significance, where the proportion of female IMGs (38.6%) was significantly greater than female USCMGs (22.2%), $p = 0.0162$.

Discussion

There has been a significant downward trend in the proportion of female trainees in radiology subspecialty training programs in the United States over the last decade (2008/09–2018/19). Females represented only 23.1% of trainees among radiology subspecialty training programs in the 2018/19 academic year, decreased from a peak of 27.1% in 2009/10. Female representation was highest within pediatric radiology (44.2%), and lowest within interventional radiology (15.7%). However, among all subspecialties, interventional radiology was the only subspecialty demonstrating a significant upward trend in the proportion of female trainees over the last decade, increased from a minimum of only 8.1% in 2008/09. The proportion of female subspecialty trainees was also found to be higher among IMGs (35.5% female) than in USCMGs (20.0% female).

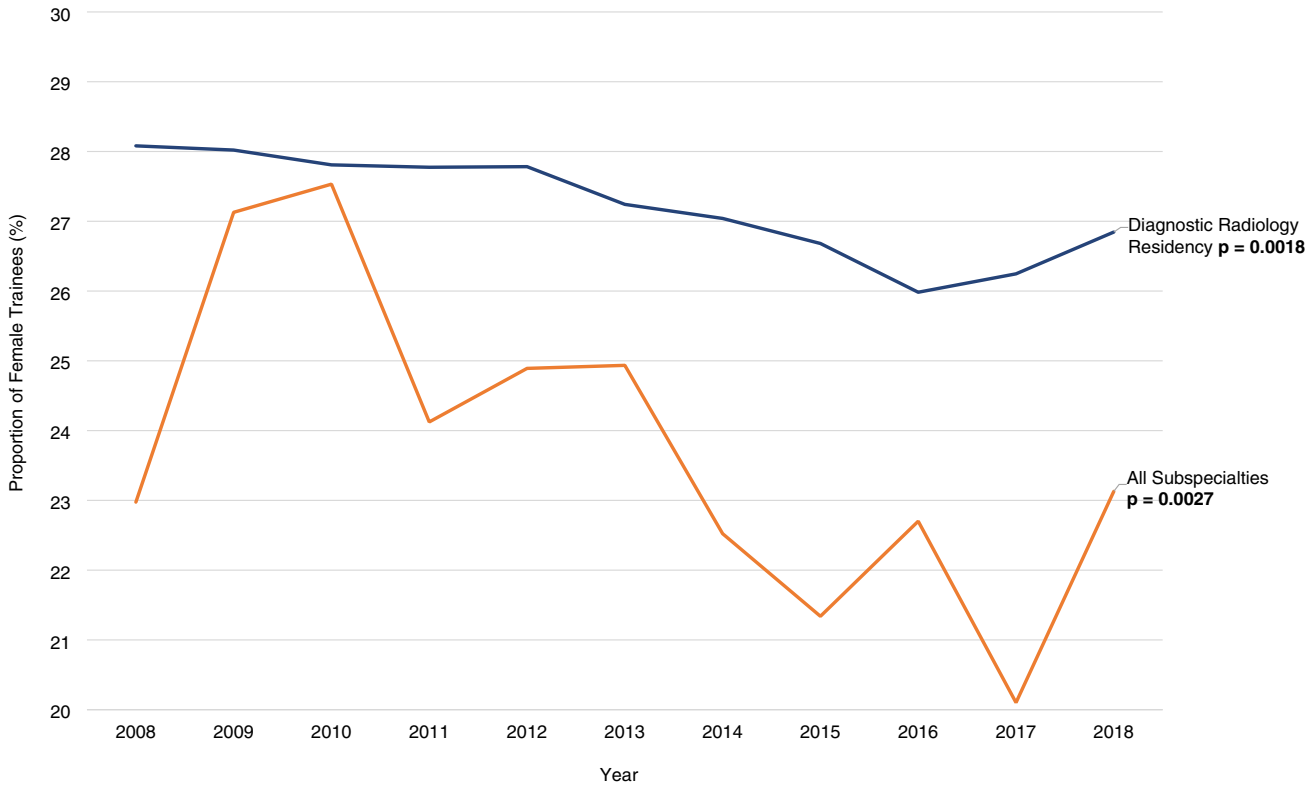

Fig. 1 Trend in gender distribution of radiology trainees over the last decade (2008/09–2018/19)

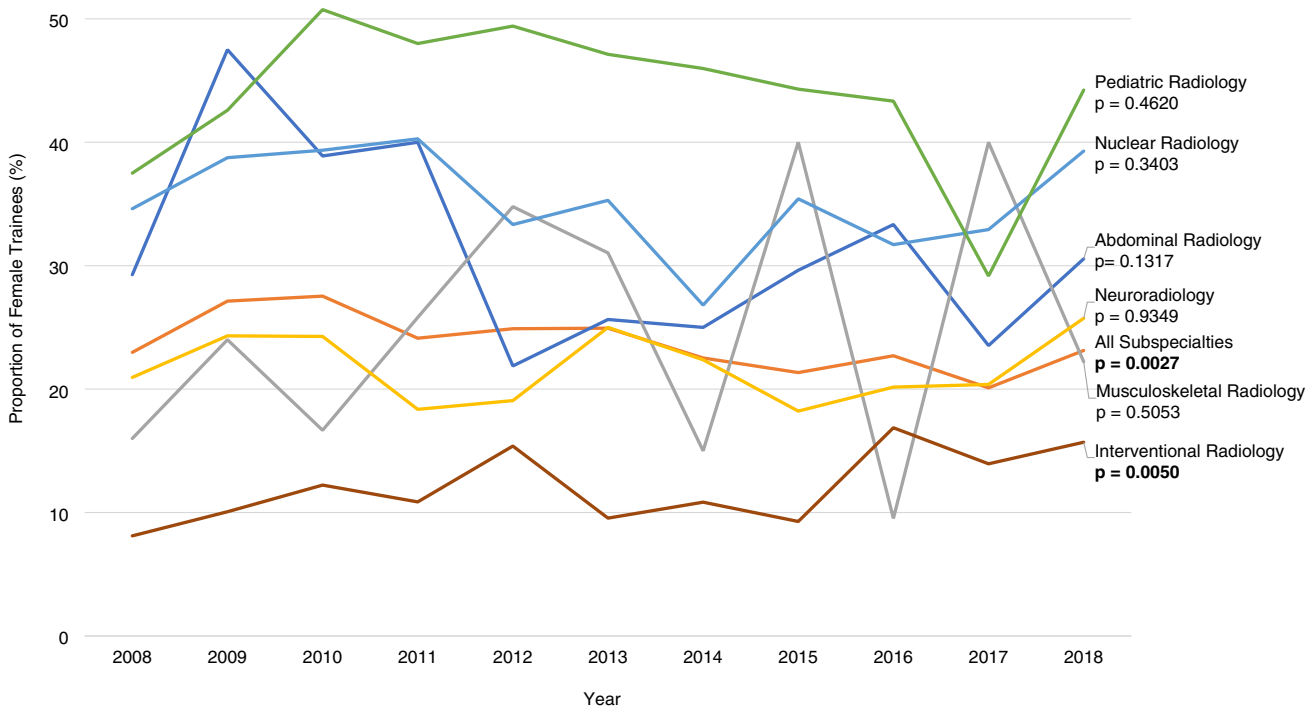

Fig. 2 Trend in gender distribution of radiology subspecialty trainees over the last decade (2008/09–2018/19)

Table 2 Gender distribution of radiology trainees according to medical school of graduation in 2018/19

ACGME accredited subspecialty	Total trainees			U.S. and Canadian Medical Graduates (USCMGs)			International Medical School Graduates (IMGs)			*p* value
	% Female (*N*)	% Male (*N*)	Total (*N*)	% Female (*N*)	% Male (*N*)	Total (*N*)	% Female (*N*)	% Male (*N*)	Total (*N*)	USCMGs vs IMGs
All subspecialties	23.1 (204)	76.9 (678)	882	20.0 (140)	80.0 (560)	700	35.5 (67)	64.6 (464)	189	**< 0.0001**
Abdominal	30.6 (11)	69.4 (24)	36	21.7 (5)	78.3 (18)	23	35.3 (6)	64.7 (11)	17	0.4774
Musculoskeletal	22.2 (6)	21 (77.8)	27	20.0 (6)	80.0 (24)	30	50.0 (1)	50.0 (1)	2	0.3952
Neuroradiology*	25.7 (61)	176 (74.3)	237	22.2 (41)	77.8 (144)	185	38.6 (22)	61.4 (35)	57	**0.0162**
Nuclear radiology†	39.3 (33)	51 (60.8)	84	28.6 (8)	71.4 (20)	28	46.4 (26)	53.6 (30)	56	0.1580
Pediatric radiology	44.2 (23)	29 (55.8)	52	39.0 (16)	61.0 (25)	41	58.3 (7)	41.7 (5)	12	0.3243
Vascular/interventional‡	15.7 (70)	376 (84.4)	446	16.3 (64)	83.7 (329)	393	11.1 (5)	88.9 (40)	45	0.5164
Diagnostic radiology residency	26.8 (1171)	3192 (73.2)	4362	26.0 (959)	74.0 (2730)	3689	32.1 (219)	67.9 (464)	683	**0.0012**

*Including Endovascular Surgical Neuroradiology

†Including Nuclear Medicine and Combined Programs

‡Including Interventional Radiology Residency

Gender disparity within radiology has received significant attention, yet despite this increased awareness and specialty-wide remedial efforts, our data show a downward trend in female trainees within radiology subspecialties. Additionally, trends in radiology leadership have also demonstrated no significant improvement in recent years [9, 30]. Indeed, improving female representation has been deemed a priority in radiology education [15]. A large component of the downward trend in subspecialty trainees may be explained by the commensurate downward trend in the pipeline of diagnostic radiology residents: if fewer females are entering diagnostic radiology residency, fewer females will enter into fellowship programs. However, the relative reduction in female subspecialty trainees (15.1%) was much larger than the relative reduction in residents (5.8%) indicating that the downward trend within residency does not fully account for the downward trend in subspecialty training.

Among the subspecialties, interventional radiology has consistently ranked the lowest in female representation [31, 32]. Several reasons for this disparity have been postulated, including the lack of exposure during medical school, lack of female mentors, and male domination resulting in structural discrimination [33, 34]. However, as demonstrated in the current study, among all subspecialties, interventional radiology was the only subspecialty which has demonstrated a significant upward trend in the proportion of female trainees over the study period. As well, female representation in interventional radiology leadership positions and in authorship metrics has increased over recent years [35]. The establishment of separate interventional radiology residency programs (allowing direct entry into interventional radiology from medical school) may explain some of this improvement. However, the interventional radiology community has also introduced a number of specific strategies to improve female representation in recent years, such as the Society of Interventional Radiology Women in IR section and the Women in IR award [32, 36]. Efforts such as these could serve as a model to improve disparity within the other subspecialties.

Pediatric radiology represents the other end of the spectrum, with near parity in gender distribution among its trainees (44.2% female). This pattern has been similar over the past ten years, and is also similar among academic pediatric radiology faculty [11]. Potential reasons for this relatively neutral distribution include a historical pattern of more female leaders and mentors in pediatric specialties and improved patient contact compared to many other radiology subspecialties [37, 38]. Nuclear radiology has similarly demonstrated a stable trend over the last decade, with well over a third of trainees in nuclear radiology being female (39.3%). Yet, relatively less data are published on the gender disparity within nuclear radiology, or reasons why the gender gap is smaller within this subspecialty. Like interventional radiology in recent years, a large

contributor toward this gender distribution likely relates to the presence of several pathways for entering nuclear radiology, some offering direct entrance from medical school and some for trainees from non-radiology backgrounds. Indeed, in pediatric radiology, it has long been suggested that there is a need to focus on the pipeline of trainees, starting in medical school, to ensure enough females are entering radiology and subsequently into their subspecialty [39]. As demonstrated by nuclear radiology (and more recently interventional radiology), it is plausible that this strategy is effective, and it may be worth further investigation within the other subspecialties.

Among all subspecialty trainees, the gender disparity was less prominent among IMGs compared to USCMGs. One possible explanation could relate to the fact that the applicant pool outside of the United States has a larger proportion of female representation. Indeed, in a recent survey, the United States had the lowest female representation in radiology among the 26 countries assessed [40]. Within subspecialties, the difference was statistically significant within neuroradiology; the lack of significance within the other subspecialties is likely on the basis of the small number of IMG trainees. Nonetheless, this improvement in gender representation among IMG trainees certainly warrants further attention.

A number of studies have outlined possible means of improving the gender gap in radiology, which generally fall into three categories: providing increased professional opportunities (such as offering greater leadership positions to females), increasing advocacy and awareness (such as increasing the visibility of accomplishments by females), and institutional performance and practices (such as increasing local efforts to retain female trainees and strengthening policies regarding career–life balance) [15]. Of these efforts, previous research has demonstrated that the percentage of females in leadership positions, female authorship, and female representation on editorial boards is increasing [41, 42]. As well, numerous publications have served as awareness for the issue of gender disparity [2, 43, 44]. However, based on the results of the current study, it would appear these efforts have not yet translated into improved gender balance among trainees. Relatively fewer publications have looked at the success of local and/or institutional efforts to reduce gender disparity; though some of these have demonstrated promising results, such as a local 'Women in Radiology' interest groups [•4]. It is possible that further effort at the local/institutional level may also play a large role in reducing gender disparity.

These data should be interpreted in the context of the study design and its limitations. While the AAMC database is comprehensive in its approach to gathering trainee data, most fellowship programs are unaccredited and are not captured by this study. Given that approximately 90–95% of radiology residents go on to do fellowships, the 882 subspecialty trainees captured in the 2018/19 cohort represents roughly only 22% of subspecialty trainees [45]. Nonetheless, one could reasonably assume that these data represent an adequate sample of the greater trainee population. A further limitation is that some subspecialties have no accredited programs, such as cardiothoracic imaging, clinical informatics, and breast/women's imaging; the latter of which is known to be more gender-neutral in distribution [46]. As well, the survey questions are based on binary gender demographic, which does not adequately account for trainees who do not identify as male or female [47]. Lastly, as the data are based on American publications, these data may not generalizable to training programs outside of the US.

In conclusion, despite increased awareness and remedial efforts, there has been a downward trend in the proportion of female subspecialty trainees over the past decade. Pediatric radiology maintains the highest female representation, while interventional radiology has the lowest. However, interventional radiology was the only subspecialty which demonstrated a significant upward trend in female representation over the study period. Among other endeavors, an increased focus on the pipeline of trainees, starting in medical school, has proven effective for interventional radiology and possibly nuclear radiology. These efforts may serve as a model toward improving representation in the other radiology subspecialties.

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Compliance with Ethical Guidelines

Conflict of interest Dr. Khosa is the recipient of the National Association of Faculties of Medicine of Canada—May Cohen Equity, Diversity and Gender Award (2020).

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