Integrated residency is associated with an increase in women among vascular surgery trainees

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ABSTRACT
Background: During the past decade, the proportion of women within graduate medical education has increased. Correspondingly, the proportion of women in almost every specialty has increased, including surgical specialties. We sought to evaluate the effect of establishing vascular surgery integrated residencies (VSIRs) on the proportion of women in vascular surgery training programs.

Methods: Resident data were obtained from the Accreditation Council for Graduate Medical Education (ACGME) Data Resource Book for the academic years 2007 to 2016. Data were collected on overall ACGME residency numbers as well as on the following surgical subspecialties: vascular, general, thoracic, neurologic, orthopedic, otolaryngologic, and urologic surgery. The number and proportion of women per year in VSIRs and vascular surgery fellowships were compared with those in the other surgical specialties.

Results: During the study period, the proportion of women in ACGME-accredited residency programs increased from 0.41 (n = 43,695/107,851) to 0.44 (n = 57,130/129,720) of residents. Since the advent of the VSIR, the number of trainees within vascular surgery has increased by 56% from 221 to 501 trainees. The proportion of women in vascular surgery training programs has increased from 0.12 (n = 27/221) to 0.33 (n = 164/501) of trainees. This increase during the 9-year study period was greater than in any other surgical subspecialty and greatest within the VSIR. Compared with fellowship training programs, integrated surgical training programs within the same subspecialty had a higher proportion of women, although variability between surgical subspecialties remained notable.

Conclusions: Although it is lower than the proportion of women within all graduate medical education training programs, an increasing proportion of women have entered vascular surgery training during the study period. This appears to be related to the introduction of VSIRs and exceeds the proportion of women entering almost all other surgical subspecialties at a rate of change faster than in all other surgical subspecialties. Further work to understand surgical specialty preferences and choice of careers after training is warranted. (J Vasc Surg 2020;71:609-15.)

Keywords: Women; Vascular surgery; Integrated residency

The United States is facing a physician shortage driven by population growth, increasing prevalence of chronic illnesses, and physicians working fewer hours and retiring earlier than in years past. In the 2018 Update prepared for the Association of American Medical Colleges, there is a predicted shortfall of between 20,700 and 30,500 surgeons by 2030.1 The supply of surgeons is not expected to change significantly in the next 10 to 15 years despite training of more surgeons because of the loss of working hours due to earlier retirement as well as fewer hours worked by the current and future workforce. The projected growth in demand easily exceeds the current and predicted supply for the next two decades.

During the same time that this physician shortage has been recognized, the proportion of women matriculating at and graduating from medical school increased to an equal number to men, and then in 2017, for the first time in history, there were more women than men in the entering medical class, constituting 50.7% of the 21,338 students entering medical school.2 Correspondingly, the number and percentage of women entering training in almost every specialty have increased, including surgical specialties.3 However, the number of women choosing surgical specialties has lagged behind medical specialties. In the past, general surgery residencies had the highest number of women in residency compared with women in residency programs for surgical subspecialties, such as neurosurgery, orthopedic surgery, and vascular surgery.4-8 With the continued relative physician shortage affecting both medical and surgical specialties,9,10 there has been a push among most specialty residency programs to attract more applicants.11,12

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A potential way to increase the number of qualified applicants has been to encourage women to pursue surgical subspecialties, and as such, they have been the target of recruitment.\textsuperscript{14,15} Historically, women have chosen primary care over surgical specialties because of the perception that surgery is dominated by an ‘old boys’ club’\textsuperscript{16} and that it is not compatible with family and lifestyle choices.\textsuperscript{17,18}

In vascular surgery, the introduction of the vascular surgery integrated residency (VSIR) has been one method used to increase the number of trainees. This became possible after 2006, when the Accreditation Council for Graduate Medical Education (ACGME) approved the primary certificate in vascular surgery, eliminating the requirement for general surgery board certification before certification in vascular surgery.\textsuperscript{19} In July 2007, the first VSIR programs were established with six residents, all men, beginning a 5- to 7-year residency training. The number of VSIR training programs has continued to increase considerably, with continued interest from competitive residency applicants.\textsuperscript{20,21}

We sought to quantify the effect of the introduction of the VSIR on increasing women trainees’ interest in vascular surgery.

METHODS

The numbers of residents in medical and surgical residencies were obtained from the ACGME Data Resource Book yearly for medical and surgical residencies from the 2007-2008 academic year to the 2016-2017 academic year. Nonsurgical specialties included anesthesia, emergency medicine, family medicine, and internal medicine. Surgical specialties included general surgery, vascular surgery, cardiothoracic surgery (CTS), orthopedic surgery, otolaryngology, plastic and reconstructive surgery (PRS), obstetrics and gynecology, and urology. The number and proportion of residents by sex were compared in medical vs surgical specialties. The VSIR and fellowship programs were analyzed together as an overall group of vascular surgery programs and separately.

Statistical analysis. The proportion of women was computed for each program by adding up all of the known trainees who are women and dividing by the total number of trainees (including those for whom sex was not reported). Linear regression was used to estimate the trend in each time series of proportion of women data—the slope of the regression line; t-tests were used to test whether estimated trends were significantly different from slopes computed for the three vascular surgery subsets (fellowship, integrated residency, and combined) as well as the difference in plateau levels for the VSIR and vascular surgery fellowship (VSF). The plateau percentage is reported as mean ± standard deviation. The Benjamini and Hochberg correction (1995) was used to control the false discovery rate. All analyses were performed in R (version 3.5.1; R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

During the study period, the proportion of women in all ACGME-accredited programs, across all specialties, increased from 0.41 (n = 43,695/107,851) to 0.44 (n = 57,150/129,720). During the 10-year study period after the establishment of VSIR programs, the total number of overall trainees in vascular surgery training programs increased by 127% from 221 to 501 trainees. This increase was primarily due to an increase in the number of trainees in VSIRs with the number of residents increasing >40-fold (6 to 260) compared with a modest increase of 12% within VSFs (215 to 241).

The proportion of women in all vascular surgery training programs increased 167.9% from 0.12 (n = 27/221) to 0.33 (n = 164/501) trainees during the study period. The increase in the absolute number and proportion of women trainees in VSIRs was greater than that in the VSF and increased from 0 (n = 0/6) in 2007-2008 to 0.36 (n = 94/260) in 2016-2017. In comparison, the proportion of women in VSFs increased from 0.13 (n = 27/215) to 0.29 (n = 70/241). The increase in the proportion of women within VSIRs was also greater than that in other surgical subspecialties (Fig 1). The majority of this increase occurred during the first 5 years that the VSIR training paradigm was available (Fig 2), with a plateau of 0.38 ± 0.02 from 2011 to 2016. The VSF also saw an increase from 2008 to 2012, with a plateau of 0.27 ± 0.02 from 2012 to 2016. The proportion of women in the VSIR plateau was significantly higher than in the VSF plateau (P < .0001).

The proportion of women was greatest in obstetrics and gynecology and family medicine residency programs at the beginning and end of the study period (Table I). The proportion of women was lowest in neurosurgery, orthopedic surgery, vascular surgery, and CTS at the beginning of the study period. By the end of the study period, the proportion of women in vascular surgery training programs had increased by 167.9% (Fig 3) and improved from the third worst to the fifth best of the 11 specialty programs examined. By comparison, the proportion of women in CTS training programs, which also introduced an integrated residency program during the study period, increased 72.3%. During the study period, the number of both the VSIR programs (programs: 6 to 53; trainees: 6 to 260 [4233%]) and the VSF programs (programs: 96 to 107; trainees: 215 to 241 [12.1%]) increased. During the same study period, the number of CTS integrated residency programs increased (programs: 0 to 27; trainees: 0 to 161 [5120% during 9 years from 2008 when the first CTS integrated residency program started]), but the number of fellowship programs decreased (programs: 81 to 69; trainees: 244 to 224.
During the study period, the number of neurosurgery (programs: 97 to 110; trainees: 843 to 1375 [63.1%]) and orthopedic surgery (programs: 153 to 168; trainees: 3259 to 3760 [15.4%]) programs and trainees increased, but the proportion of women in neurosurgery and orthopedic surgery training programs remained among the lowest of the specialties.

The slope of the regression line created from linear regression was used to estimate the time series of proportion of women trainees in each surgical subspecialty (Table II). The VSIR slope was significantly different from the slopes for all other surgical subspecialties (PRS combined, $P = .001$; PRS fellowship, $P = .0000016$; PRS integrated residency, $P = .04$; CTS, combined, $P = .0000053$; CTS fellowship, $P = .0000013$; CTS integrated residency, $P = 4.8 \times 10^{-15}$; general surgery, $P = .0000044$; otolaryngology, $P = .0000022$; genitourinary surgery, $P = .0000017$; neurosurgery, $P = .0000013$; orthopedic surgery, $P = 1.4 \times 10^{-18}$). The slope for VSF was significantly different from the slopes for PRS fellowship, CTS combined, CTS fellowship, CTS integrated residency, general surgery, otolaryngology, genitourinary surgery, neurosurgery, and orthopedic surgery ($P = .0065$, .026, $3.8 \times 10^{-9}$, .035, .006, .024, and .0012, respectively). The slope for vascular surgery combined was significantly different from the slopes for PRS fellowship, CTS combined, CTS fellowship, CTS integrated residency, general surgery, otolaryngology, genitourinary surgery, neurosurgery, and orthopedic surgery ($P = 1.2 \times 10^{-4}$, $2.0 \times 10^{-3}$, $7.1 \times 10^{-4}$, $1.1 \times 10^{-10}$, $1.7 \times 10^{-5}$, $1.0 \times 10^{-3}$, $1.1 \times 10^{-4}$, $6.5 \times 10^{-4}$, and $1.3 \times 10^{-5}$, respectively).

In looking solely at surgical programs with both an integrated residency track and a fellowship track, the trend for an increasing proportion of women was significantly higher for all of the integrated residencies analyzed...
Table I. Proportion of women within Accreditation Council for Graduate Medical Education (ACGME)-accredited training programs in the academic years 2007-2008 and 2016-2017

<table>
<thead>
<tr>
<th></th>
<th>2007-2008</th>
<th>2016-2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>All programs</td>
<td>0.41</td>
<td>0.44</td>
</tr>
<tr>
<td>Family medicine</td>
<td>0.52</td>
<td>0.54</td>
</tr>
<tr>
<td>Internal medicine</td>
<td>0.37</td>
<td>0.40</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>0.11</td>
<td>0.17</td>
</tr>
<tr>
<td>Obstetrics and gynecology</td>
<td>0.75</td>
<td>0.82</td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>0.27</td>
<td>0.35</td>
</tr>
<tr>
<td>PRS combined</td>
<td>0.22</td>
<td>0.37</td>
</tr>
<tr>
<td>General surgery</td>
<td>0.27</td>
<td>0.37</td>
</tr>
<tr>
<td>Vascular surgery combined</td>
<td>0.12</td>
<td>0.33</td>
</tr>
<tr>
<td>CTS combined</td>
<td>0.13</td>
<td>0.23</td>
</tr>
<tr>
<td>Urology</td>
<td>0.20</td>
<td>0.26</td>
</tr>
</tbody>
</table>

CTS, Cardiothoracic surgery. PRS, plastic and reconstructive surgery.

The data presented for the three training programs with both an integrated residency and a fellowship pathway (plastics and reconstructive surgery combined, vascular surgery combined, and cardiothoracic surgery combined) comprise the total number of women trainees for both pathways divided by the total number of training positions for both pathways.

Fig 3. Percentage change in the proportion of women within Accreditation Council for Graduate Medical Education (ACGME)-accredited training programs between the academic years 2007-2008 and 2016-2017.

This study demonstrates that since the development of the VSIR, the number of women in VSIR programs has increased at a faster rate than in any other surgical subspecialty training programs. The proportion of women overall in vascular surgery training programs had the greatest increase (167.9%) from 0.13 to 0.33, and this was primarily due to the increase in the absolute number and proportion of women in the VSIR but is also a reflection of the extremely low numbers of women in vascular surgery at the beginning of the study period. Interestingly, the effect was not isolated to the VSIR as the proportion of women in VSF programs also increased significantly more than in most of the other surgical specialties within the same time period, although to a slightly lesser degree. This is likely a reflection of many different efforts to increase women in vascular surgery, including the Society for Vascular Surgery (SVS) and its programs in mentoring, as well as an increased acceptance of women overall in surgical programs, given that the majority of surgery programs had a positive slope during the study period. At the same time, the number of unfilled VSF positions in the match has decreased to an average of 7.8% (range, 2.5%-14.9%) during the same 10-year study period.20 Although the proportion of women in VSIR during the last 5 years and in VSF during the last 4 years of the study period reached plateaus, the proportion of women in vascular surgery programs continues to increase because the number of available VSIR training positions continues to increase. However, these plateaus suggest that the proportion of women in vascular surgery training will not increase further without additional changes to attract women to the field. Although the proportion of women in combined CTS increased over time, this was primarily due to an increasing number of CTS integrated residency trainees, which had a higher proportion of women than CTS fellowship, similar to vascular surgery. The actual proportions of women in CTS integrated residency and CTS fellowship have been essentially stable during the last 7 years, and the combined curve has now reached the approximate plateau level for CTS integrated residency, suggesting that the proportion of women in CTS training programs will not increase further unless other changes are made to attract more women to the field.

More so than any other surgical subspecialty, vascular surgery, with a primarily older population of patients, faces a significant challenge as the number of aging Americans increases faster than ever in the past. The “silver tsunami” is upon us, and the rapid increase in the aging population creates a widening gap in the number of vascular surgeons in practice vs the number needed to...
offer care. To address this vascular surgery shortage, the number of VSF positions was deliberately increased steadily in the 1990s through the early 2000s. However, the number of applicants has remained stagnant for many years and in fact began to decrease in the 2000s, coming to a nadir in the years 2004 and 2005 when 20% of the VSF positions remained unfilled in the match.22 Shortly thereafter, in 2006, the primary certificate in vascular surgery was approved, obviating the need for general surgery training before vascular surgery training. At that time, with the convergence of these two events, it was recognized that women were underrepresented in vascular surgery. In 2005, of all training programs using the Electronic Residency Application Service, vascular surgery had the lowest proportion of women applicants at 0.18,8 and only 17% of vascular surgery fellows were women compared with 24.7% of general surgery residents.8

Women represented only 0.5% of membership in the SVS in 1985, which increased to 5.6% in 2010 and 13% in 2016. With the creation of the VSIR, an increasing number of women are applying and ranking VSIR programs in the National Resident Matching Program, representing 40% of the applicants to a top program in 2009.21 In all programs, the number of women applicants has increased from 16% in 2008 to 27% in 2015.20

The leaders of vascular surgery had the foresight in the early 2000s to obtain approval of a primary certificate in vascular surgery and to make a deliberate effort to increase the applicant pool by attracting qualified candidates who are women to vascular surgery. This coincided nicely with the establishment of new VSIR programs in 2006. With the efforts of vascular surgery leadership and program directors, the number of women in VSIR has grown at an astonishing rate, and VSIR is now among the top surgical programs for the proportion of women. For comparison, the CTS training programs experienced a 72.3% increase in the proportion of women in their training programs from 0.13 to 0.23 during the study period. CTS similarly had an extremely low proportion of women at the beginning of the study period as well as the addition of an integrated residency in recent years. Their first integrated residency programs were established in 2008, a year later than vascular surgery, but the proportion of women has increased at a slower rate in comparison. Interestingly, the proportion of women in neurosurgery and orthopedic surgery was among the lowest at the beginning of the study period and remained low throughout the study period. However, in looking solely at surgical programs with both an integrated residency track and a fellowship track, the trend for an increasing proportion of women was significantly higher for all of the integrated residencies analyzed. This supports the hypothesis that integrated residencies are more attractive than fellowship tracks to trainees who are women. The VSIR was meant to attract a new “generation” of medical students with a desire for more lifestyle-friendly surgical subspecialties.23 The primary attraction to VSIR over VSF is the direct pathway from medical school, resulting in a shorter training paradigm with earlier entry into vascular surgery practice.15 This has led to a dramatic increase in competitive applicants to vascular surgery, irrespective of sex. One possible explanation that has been suggested in the past is that vascular surgery offers a wide range of practice types, some of which are considered lifestyle friendly. This has been proposed as a primary reason for an increase in women (more so than men) choosing vascular surgery. However, studies have shown that among the millennial generation, an increasing proportion of men and women alike are choosing specialties with controllable lifestyles.24 On the other hand, while choosing a career based on lifestyle has not been different among men and women, women have traditionally shown more interest in shorter training programs.24,25 Thus, the increase in the number and proportion of women in VSIR programs may reflect a decrease in those women

### Table II. Slope of the regression lines created from linear regression estimating the time series of proportion of women trainees in each surgical subspecialty

<table>
<thead>
<tr>
<th>Training program</th>
<th>Regression line slope</th>
<th>P nonsignificant vs vascular training program</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSIR</td>
<td>0.033</td>
<td>None</td>
</tr>
<tr>
<td>Vascular surgery combined</td>
<td>0.025</td>
<td>PRS integrated residency, PRS combined</td>
</tr>
<tr>
<td>Vascular surgery fellowship</td>
<td>0.019</td>
<td>PRS integrated residency, PRS combined, CTS combined, general surgery</td>
</tr>
<tr>
<td>PRS integrated residency</td>
<td>0.022</td>
<td>N/A</td>
</tr>
<tr>
<td>PRS combined</td>
<td>0.017</td>
<td>N/A</td>
</tr>
<tr>
<td>PRS fellowship</td>
<td>0.0055</td>
<td>N/A</td>
</tr>
<tr>
<td>CTS integrated residency*</td>
<td>−0.016</td>
<td>N/A</td>
</tr>
<tr>
<td>CTS combined</td>
<td>0.098</td>
<td>N/A</td>
</tr>
<tr>
<td>CTS fellowship</td>
<td>0.0080</td>
<td>N/A</td>
</tr>
<tr>
<td>General surgery</td>
<td>0.0086</td>
<td>N/A</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>0.0090</td>
<td>N/A</td>
</tr>
<tr>
<td>Urology</td>
<td>0.0053</td>
<td>N/A</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>0.0078</td>
<td>N/A</td>
</tr>
<tr>
<td>Orthopedic surgery</td>
<td>0.0027</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*The slope for cardiothoracic surgery integrated residency is negative because in the first 2 years when the program was offered, there were 40% and 36% women, respectively. From 2010 to 2016, the average population of women was 23.3%.
interested in vascular surgery who are no longer dismissing their interest in vascular surgery because of the length of training required. This effect is reproduced in those surgical subspecialties that have established integrated residencies, including CTS and PRS. However, this effect has been greatest in vascular surgery.

This observation is likely due to a multitude of factors. An important factor is likely the valuable mentorship opportunities that translated into increased interest from women. The SVS has made a substantial investment in recruiting talented young minds to vascular surgery with traveling scholarships to the Vascular Annual Meeting, paired mentorship sessions, and the formation of vascular surgery interest groups at medical schools. The vascular surgery leadership in the United States has done a phenomenal job in increasing women in vascular surgery training and therefore practice. At this time, it is not possible to ascertain whether these efforts have translated to a similar increase in the proportion of women in the SVS membership and academic faculty at the associate professor level, where we would expect to see an effect. Therefore, we as a specialty have an opportunity to lead in the surgical world and to fix the “leaky pipeline” phenomenon by continuing to recruit the best trainees, women and men, decreasing attrition and increasing our promotion of women within academic faculty.

CONCLUSIONS

In the past decade, there has been a continuing increase in the number and proportion of women in nearly every nonsurgical and surgical specialty training program. Vascular surgery, similar to most of the surgical specialties, has been predominantly composed of men, but there has been a recent dramatic increase in women entering vascular surgery training, which is likely partially but not completely due to the establishment of VSIR programs.

AUTHOR CONTRIBUTIONS

Conception and design: SHS, SS
Analysis and interpretation: SHS, GT, SS
Data collection: SHS
Writing the article: SHS, SS
Critical revision of the article: SHS, CT, SS
Final approval of the article: SHS, CT, SS
Statistical analysis: GT
Obtained funding: Not applicable
Overall responsibility: SHS

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