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Disparities in Research during Plastic Surgery Training: How Can We Level the Playing Field?

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Background: Lack of female and ethnically underrepresented in medicine (UIM) surgeons remains concerning in academic plastic surgery. One barrier to inclusion may be unequal opportunity to publish research. This study evaluates the extent of this challenge for plastic surgery trainees and identifies potential solutions.
Methods: Data were collected on academic plastic surgeons' research productivity during training. Bivariate analysis compared publication measures between genders and race/ethnicities at different training stages (pre-residency/residency/clinical fellowship). Multivariate analysis determined training experiences independently associated with increased research productivity.
Results: Overall, women had fewer total publications than men during training (8.89 versus 12.46, $P = 0.0394$). Total publications were similar between genders before and during residency ($P > 0.05$ for both) but lower for women during fellowship (1.32 versus 2.48, $P = 0.0042$). Women had a similar number of first-author publications during training (3.97 versus 5.24, $P = 0.1030$) but fewer middle-author publications (4.70 versus 6.81, $P = 0.0405$). UIM and non-UIM individuals had similar productivity at all training stages and authorship positions ($P > 0.05$ for all). Research fellowship completion was associated with increased total, first-, and middle-author training publications ($P < 0.001$ for all).
Conclusions: Less research productivity for female plastic surgery trainees may reflect a disparity in opportunity to publish. Fewer middle-author publications could indicate challenges with network-building in a predominately male field. Despite comparable research productivity during training relative to non- UIM individuals, UIM individuals remain underrepresented in academic plastic surgery. Creating research fellowships for targeting underrepresented groups could help overcome these challenges. *(Plast Reconstr Surg Glob Open 2022;10:e4301; doi: 10.1097/GOX.0000000000004301; Published online 6 May 2022.)*

INTRODUCTION

Lack of diversity among plastic surgeons remains a persistent challenge, and efforts to explain and address this issue are ongoing.[1–4] Academic plastic surgery faculty in the United States are composed of less than 20% women[5] and only 5% individuals from ethnically underrepresented in medicine (UIM) backgrounds.[6] The Association of American Medical Colleges defines UIM as individuals from African American, Latino, and indigenous (American Indian/Alaskan Native, and Native Hawaiian/other Pacific Islander) backgrounds. To expand representation of individuals from these groups in our field, one major objective should be to identify potential disparities in professional development opportunities for women and UIM individuals, beginning at the medical student level and progressing up the academic plastic surgery ladder.

One potential equity growth area for academic plastic surgery is in opportunities to conduct and publish research. These experiences are essential to improving the field's practices, and they provide plastic surgeons with knowledge and skills to answer scientific questions that they may have throughout their careers. Research productivity is also associated with career advancement at all stages of plastic surgery training (pre-residency/

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residency/clinical fellowship) and at the faculty level.[7–14] Thus, disparities in research opportunities for women and UIM individuals could serve as an unfair barrier for those who strive to establish careers in academic plastic surgery.

The current literature on disparities in plastic surgery research opportunities is limited, but studies have revealed that inequities in this area may exist for underrepresented groups. A consistent finding across studies is that female assistant professors have fewer publications than their male peers; so discussion has largely focused on gender-based inequity of opportunity at the junior faculty level.[15,16] Recently, one study in the general surgery literature indicated that similar challenges may also exist for UIM faculty.[17] However, with research productivity of plastic surgery trainees on the rise,[14,18] it is possible that differences in research productivity among faculty may actually originate at the trainee level and reflect inequities during plastic surgery training. Studying the research productivity of academic plastic surgeons before their faculty appointments may bring some clarity to this potential challenge and inform the development of possible solutions.

In this study, we conduct a comprehensive analysis of the research productivity during different stages of training (pre-residency/residency/clinical fellowship) for academic plastic surgeons in the United States. The primary objective was to identify differences in training research productivity for women and UIM individuals that may reflect disparate opportunities for individuals from these groups to conduct and publish research. A secondary objective was to identify other training experiences that may be utilized to increase research productivity and level the playing field for all aspiring academic plastic surgeons.

Takeaways

Question(s): (1) Are there differences in research productivity while in training for academic plastic surgeons relative to gender or race/ethnicity; and (2) Are there training experiences associated with increased research productivity that may be used to level the playing field?

Findings: Women had fewer total publications than men during training, with those primarily being middle-author publications. UIM and non-UIM faculty had similar productivity at all training stages. Research fellowship completion was associated with increased total publications during training.

Meaning: Less research productivity for female plastic surgery trainees may reflect challenges with network-building, and research fellowships targeting underrepresented groups should be explored to address these challenges.

METHODS

Identification of Surgeons and Inclusion Criteria

A search for academic plastic surgeons in the United States was performed in October 2020. Lists of integrated and independent plastic surgery residency programs were obtained from the American Council of Academic Plastic Surgeons website (acaplasticsurgeons.org). Faculty lists were then obtained from each residency program's website. Faculties included for further data collection were those listed as assistant professors, associate professors, and professors. Individuals were then excluded if they were designated as adjunct or voluntary, or if they had not completed plastic surgery residency training. To control for length of plastic surgery training across faculty members, only individuals who completed integrated (ie, not independent) plastic surgery residency were included in our training research productivity analysis.

Data Collection

Training experience data were collected primarily from faculty biographies on residency program websites. Missing data points were obtained from Doximity (San Francisco, Calif.), LinkedIn (Sunnyvale, Calif.), and other public-access websites. Surgeons were deemed to have completed a research fellowship if it was completed before they finished their clinical training (residency or final clinical fellowship). Advanced degrees included all graduate degrees in addition to MD or DO. Institution ranking was determined using US News and World Report (New York, N.Y.) 2021 research ranking for medical school and Doximity 2020–2021 integrated plastic surgery research ranking for residency. Doximity research ranking is based on a formula that objectively measures the research productivity of a residency program's current residents and recent graduates.[19]

Research productivity (ie, number of publications) was collected using Scopus (scopus.com, Reed Elsevier, London, UK). According to our group's previously published methods,[14,20] an individual's research during training was defined as all publications dated up to and including the year of their last stage of clinical training (residency or final clinical fellowship). Pre-residency research was defined as all publications dated before and including an individual's last year of medical school. Research during residency was defined as all publications dated after an individual's last year of medical school and up to and including their last year of residency. Research output during clinical fellowship was defined as all publications dated after an individual's last year of residency and up to and including the last year of their final clinical fellowship. Individual publications at each stage were reviewed for authorship position. Middle-author was defined as all author positions other than first or last author. If an individual was the only author listed, this was considered to be a first-author publication.

Determination of faculty demographic data (women/men and UIM/non-UIM status) was conducted by two independent reviewers (FD and MPM) based on faculty names and photographs. Non-UIM designation included White and Asian individuals, and UIM designation included individuals with African American, Latino, and Indigenous (American Indian/Alaskan Native, Native Hawaiian/other Pacific Islander) backgrounds.

Data Analysis

Proportion of individuals from each demographic group who completed various academic training experiences was compared using chi-square and Fisher exact tests. Descriptive statistics (mean ± standard error of mean) were calculated for number of publications for each demographic group, at each training stage, and for each author position. Bivariate analysis using student *t*-tests compared female versus male trainees and UIM versus non-UIM trainees. Multivariate logistic regression was used to determine training experiences that were independent predictors of increased training research productivity while controlling for multiple possible confounders. A *P* value less than 0.05 was considered significant for all comparisons. All statistical analyses were completed using IBM SPSS (version 25.0; IBM Corporation, Armonk, N.Y.) and GraphPad Prism 8.0 (GraphPad Software, San Diego, Calif.).

RESULTS

Academic Training Experiences by Gender and Ethnicity

In total, 287 academic plastic surgery faculty members were found to have completed an integrated plastic surgery residency and were included for analysis. This included 90 women and 197 men, as well as 15 UIM individuals and 272 non-UIM individuals (Table 1). Comparing women with men and UIM with non-UIM individuals, no differences were observed in research-related academic training experiences, including completion of an MD-PhD, other advanced degree, or research fellowship.

Training Research Productivity for Women and Men

Overall, women had significantly fewer publications during training than men (8.89±0.97 versus 12.46±1.08, $P = 0.0394$) (Table 2). Women and men produced similar numbers of publications before residency and during residency ($P > 0.05$ for both), but women had fewer publications during clinical fellowship (1.32±0.19 versus 2.48±0.26, $P = 0.0042$). During training, number of first-author publications did not differ between groups (3.97±0.41 versus 5.24±0.49, $P = 0.1030$), but women had statistically significantly fewer middle-author publications (4.70±0.67 versus 6.81±0.62, $P = 0.0405$). No significant differences in first- or middle-author publications were observed before and during residency ($P > 0.05$ for all). During clinical fellowship, number of first-author publications was again similar between genders (2.91±0.31 versus 3.80±0.41, $P = 0.0896$), but women had significantly fewer middle-author publications (0.57±0.10 versus 1.36±0.16, $P = 0.0015$).

Table 1. Academic Training Experiences by Gender and Ethnicity

	Women	Men	*P*
Training experience, n (%)	*n = 90*	*n = 197*	
Advanced degree	17 (19)	37 (19)	0.983
MD-PhD	9 (10)	14 (7)	0.402
Research fellowship	12 (13)	20 (10)	0.427
	UIM	Non-UIM	
Training experience, n (%)	*n = 15*	*n = 272*	
Advanced degree	2 (13)	52 (19)	0.745
MD-PhD	1 (7)	22 (8)	1.000
Research fellowship	3 (20)	29 (10)	0.227

Chi-square tests and Fisher exact tests were used to compare proportions of individuals that pursued various research experiences for men versus women and for UIM versus non-UIM individuals. Significant values ($P < 0.05$) are denoted with asterisks.
UIM, ethnically underrepresented in medicine.

Training Research Productivity of UIM and Non-UIM Individuals

Of the 287 included surgeons, 15 were UIM individuals and 272 were non-UIM individuals (Table 3). During training, UIM and non-UIM individuals produced a similar number of publications (10.87±2.99 versus 11.37±0.84, $P = 0.8902$). Total number of publications was also similar at each individual stage of training ($P > 0.05$ for all). No significant differences between groups were observed for number of first- or middle-author publications at any stage of training ($P > 0.05$ for all).

Independent Predictors of Increased Training Research Productivity

Independent predictors of total, first-author, and middle-author training publications are detailed in Table 4. Male gender was a significant predictor of increased total training publications ($P = 0.029$) and middle-author publications ($P = 0.023$), but not first-author publications ($P = 0.100$). UIM status was not a significant independent predictor of any category of training publications ($P > 0.05$ for all). Attending a residency program with higher research ranking and having completed a research fellowship were significant independent predictors of increased total, first-author, and middle-author publications during training ($P < 0.05$ for all).

DISCUSSION

Given the importance of research productivity for career progression in plastic surgery, disparity in opportunity to conduct and publish research may serve as a barrier to inclusion in our field. In this study, we examined

Table 2. Training Research Output for Men and Women

	Women, Mean ± SEM	Men, Mean ± SEM	*P*
Training	*n = 90*	*n = 197*	
Total publications	8.89±0.97	12.46±1.08	0.0394*
First author	3.97±0.41	5.24±0.49	0.1030
Middle author	4.70±0.67	6.81±0.62	0.0405*
Pre-residency	*n = 90*	*n = 197*	
Total publications	1.57±0.24	1.65±0.23	0.8375
First author	0.60±0.09	0.63±0.10	0.8209
Middle author	0.90±0.14	0.97±0.14	0.7660
During residency	*n = 90*	*n = 197*	
Total publications	6.26±0.82	8.72±0.87	0.0799
First author	2.91±0.31	3.80±0.41	0.1728
Middle author	3.34±0.60	4.70±0.50	0.1068
During clinical fellowship	*n = 72*	*n = 161*	
Total publications	1.32±0.19	2.48±0.26	0.0042*
First author	0.72±0.11	1.08±0.13	0.0896
Middle author	0.57±0.10	1.36±0.16	0.0015*

Student *t*-tests were used to compare mean publications for women versus men at different stages of training. "During clinical fellowship" data only include individuals who completed a clinical fellowship.
*Significant values ($P < 0.05$).

Table 3. Training Research Output for Trainees from UIM and Non-UIM Individuals

	UIM, Mean ± SEM	Non-UIM, Mean ± SEM	*P*
Training	*n = 15*	*n = 272*	
Total publications	10.87±2.99	11.37±0.84	0.8902
First author	4.73±1.33	4.85±0.38	0.9435
Middle author	5.87±2.02	6.17±0.49	0.8898
Pre-residency	*n = 15*	*n = 272*	
Total publications	1.13±0.48	1.65±0.18	0.5168
First author	0.40±0.19	0.60±0.08	0.5922
Middle author	0.67±0.34	0.96±0.11	0.5426
During residency	*n = 15*	*n = 272*	
Total publications	8.53±2.43	7.92±0.68	0.8337
First author	3.87±1.11	3.50±0.31	0.7851
Middle author	4.47±1.58	4.27±0.40	0.9085
During clinical fellowship	*n = 13*	*n = 226*	
Total publications	1.39±0.42	2.17±0.20	0.3477
First author	0.54±0.21	1.00±0.10	0.2834
Middle author	0.85±0.41	1.12±0.12	0.5829

Student *t*-tests were used to compare mean publications for UIM versus non-UIM individuals at different stages of training. "During clinical fellowship" data only include individuals who completed a clinical fellowship. Significant values ($P < 0.05$) are denoted with asterisks.
UIM, ethnically underrepresented in medicine.

how research productivity during plastic surgery training stages (pre-residency/residency/clinical fellowship) may differ for individuals from underrepresented groups and what other experiences may influence training research productivity. Our principal findings were (1) female trainees finish plastic surgery training with fewer publications than male trainees; (2) female trainees have similar number of first-author publications but fewer middle-author publications versus male trainees; (3) there were no differences in productivity between UIM versus non-UIM trainees; and (4) completing research fellowships during training independently predicts increased total, first-, and middle-author training research productivity. Herein, we discuss how these findings may reveal underlying disparity in opportunity for trainees from underrepresented groups, and what possible solutions may also be gleaned from our data.

To our knowledge, this is the first study to demonstrate gender-based differences in research productivity at the trainee level in plastic surgery. Other studies on this topic in the plastic surgery literature have mainly focused on productivity at the faculty level and demonstrated lower research output among female junior faculty versus their male peers.[15,16,21] Although our findings suggest this difference may arise earlier than previously described, some proposed explanations for gender-based differences in research productivity among junior faculty may also apply to trainees. Mentorship and difficulty finding gender-concordant research mentors in a predominately male field is one likely source.[15,22–24] Compared with junior faculty, this explanation may be even more applicable to trainees, who often require more guidance from mentors to identify research questions and resources for answering them. Gender imbalance in time taken for pregnancy and familial responsibilities may also apply to some female trainees,[25,26] requiring them to divert more of their attention away from research compared with their male peers.[15,23] Although we did not directly measure the impact of mentorship, pregnancy, and familial responsibilities on training research productivity for different genders, these factors likely contribute to the findings in our study and warrant further investigation.

Table 4. Independent Predictors of Increased Publications during Training

Independent Factors	Total, *P*	First Author, *P*	Middle Author, *P*
Men versus women	0.029*	0.100	0.023*
UIM versus non-UIM	0.469	0.498	0.513
Medical school ranking	0.923	0.805	0.837
Residency program ranking	<0.001*	0.001*	<0.001*
Advanced degree (yes or no)	0.609	0.255	0.959
Clinical fellowship (yes or no)	0.145	0.064	0.303
Research fellowship (yes or no)	<0.001*	<0.001*	<0.001*

Multivariate logistic regression was used to assess for independent predictors of increased training publications. Dependent variables included total, first, and middle-author publications, and a separate regression was performed for each outcome. Independent variables used for each analysis are shown in the first column. *P* values are included in the table. Significant values ($P < 0.05$) are denoted with asterisks.
UIM, ethnically underrepresented in medicine.

Importantly, we also showed that gender-based differences observed in our study may be driven by significant differences in number of middle-author publications, which may reveal other challenges faced by female trainees. Unlike first authors, who consistently make major contributions to conception and execution of research studies, the role of the middle author is less well-defined.[27] Caturegli et al argued that this ambiguity means assignment of middle-author positions may be influenced by "softer factors" like gender dynamics and interpersonal interactions, which may disadvantage women in predominately male fields.[28] Middle-author roles may also be allocated to close research collaborators, and thus the number of middle-author publications may correlate to the size of individuals' academic networks,[29] which have been shown to be smaller for women in academia.[30] Our finding that men had significantly more middle-author publications during fellowship but not residency or medical school may signify greater network growth throughout training for male trainees compared with their female counterparts.

Given the multifactorial cause of this problem, a number of viable strategies exist for pursuing gender equity in research productivity and, in turn, academic representation. First, it should be the responsibility of all authors to ensure that authorship positions are assigned based on contribution to the article rather than on some of the "softer factors" discussed by Caturegli et al. Likewise, when evaluating candidates for plastic surgery training and faculty positions, interviewers should devote time to assessing the contribution to publications listed in candidates' CVs, especially for those with a significant number of middle-author publications. Furthermore, efforts aimed at growing the academic network of female trainees could also be pursued. Traditional routes for expanding one's academic network include participating in surgical societies and attending academic conferences, where trainees can meet others with similar academic interests and establish plans for future collaboration. One regional society has started to develop programs for involvement of women

and mentorship of trainees, and they have also reported an increase in female registrants at their annual conference.[31] Other professional organizations in plastic surgery could create similar opportunities, and future studies may analyze how these initiatives foster network-building and research productivity for participants.

In our other analysis of differences in training research productivity for underrepresented groups, we found that UIM trainees had similar productivity compared with their non-UIM peers. On the one hand, our findings in this area are quite encouraging, as they suggest that the field of plastic surgery may be creating equitable opportunities for UIM trainees to participate in and publish research. However, despite similar training research productivity compared with non-UIM trainees, UIM individuals comprised only 5% of our faculty cohort, which signifies that barriers outside the realm of research exist for broadening inclusion of UIM individuals in academic plastic surgery. More work is needed to identify these specific barriers and to develop strategies for overcoming them.

Notably, findings from our multivariate analysis highlight one experience, the research fellowship, as a tool that may be utilized to help address many of the problems discussed in this study. Established benefits of completing a plastic surgery research fellowship during residency include attaining mentors, receiving funds to attend conferences, and developing the investigative skillset to lead future research projects.[32] More recently, others have shown that plastic surgery research fellowships for medical students may also enable increased research productivity before residency.[33] This is further supported by our finding that completing a research fellowship at any stage of training is an independent predictor of increased training research productivity. Other specialties have seemed to recognize these fellowships as opportunities for preparing individuals from underrepresented groups for careers in their field, and they have started to establish paid research fellowships specifically for women and UIM individuals.[34] We advocate that plastic surgery follows suit. Launching and maintaining these fellowships is not without challenges,[35] but the potential payoff of preparing a group of diverse individuals for entry into academic plastic surgery may be well worth the investment.

Despite the important findings in our study, our methodology comes with a few notable limitations. First, we collected our data from online sources that may not be completely updated or accurate. Second, we were unable to comprehensively study if an integrated plastic surgery program was present at the medical school of these trainees while they were medical students, which also may be advantageous to their pre-residency research productivity.[36] Third, research published during each stage of the plastic surgery training pathway may not necessarily reflect research conducted at that specific stage. To account for this, we attributed all publications from the last year of each stage of training to that particular stage, where the bulk of the research was most likely conducted. However, the long publication lag in some journals may mean that some publications are attributed to the subsequent stage of training.[37–39] Fourth, we assigned UIM status using photographs and names as opposed to self-reported race/ethnicity data, which was not available. Although others have used this method previously,[3] we acknowledge that our assigned racial/ethnic groups may not actually reflect the self-identified race/ethnicity of individuals in our study. Finally, we recognize that other metrics of success besides research productivity may better reflect an individual's contribution to academia, but these metrics are outside the scope of this study.

CONCLUSIONS

During plastic surgery training, female trainees produce fewer publications than their male peers, which may indicate disparate opportunities to conduct research and may create a significant challenge for career advancement in academic plastic surgery. Although women have a similar number of first-author publications during training, they have fewer middle-author publications, which may reflect difficulty with network-building in a predominately male field. Despite comparable research productivity during training relative to non-UIM individuals, UIM individuals remain underrepresented in academic plastic surgery, and more initiatives are needed to promote their inclusion. Creation of research fellowships reserved for trainees from underrepresented groups could help mitigate barriers to inclusion of these individuals in the academic plastic surgery workforce. Follow-up studies are needed to continue to monitor disparities in research productivity among plastic surgery trainees.

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