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Program Directors Research Productivity and Other Factors of Anesthesiology Residency Programs That Relate to Program Doximity Ranking

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Introduction

An analysis of the 2016 National Resident Matching Program revealed that the number of residency program positions offered increased by 242% since 1986.[1] In recent years, anesthesiology has become an increasingly popular specialty within the medical field. The perception of anesthesiology as a career with a controllable lifestyle, the increased participation of women in the physician workforce, and the 2014 enactment of the Accreditation Council for Graduate Medical Education (ACGME) Next Accreditation System are among the major factors responsible for the significant expansion of anesthesiology residency programs.[1,2] Program directors (PDs) of anesthesiology residency programs take on the enormous responsibility of choosing only the most promising trainees among this ever-increasing pool of qualified applicants. Consequently, PDs play a critical role in establishing the culture within their programs.

Various factors, such as training, leadership, clinical volume, and research productivity, determine academic performance. Although efforts exist to include all of these features in the evaluation of faculty members, research production remains the central determinant of academic standing. The ACGME sets formal standards for residency programs and the official responsibilities of a PD, one of which is participation in scholarly activities.[3] Through basic and clinical research, PDs are expected to provide the wisdom and institutional means necessary to support and mentor the next generation of anesthesiology physician scientists.[4,5] Given the degree of influence that PDs have over resident education, it seems sensible to evaluate the research productivity of the PDs themselves. But although a number of studies in the existing literature analyze the academic credentials of anesthesiology residency applicants,[4,6-9] comparatively few studies exist that highlight the attributes of PDs themselves. Of the few studies that do exist,[3,5,10] none have explored the relationship between the PDs' research productivity and their academic rank, nor with the overarching rank of their residency program.

The objective of this study was to investigate the relationship between the research productivity of anesthesiology PDs and the national ranking of their programs and to identify further program characteristics that could affect Doximity ranking. We decided to include all of the program-related factors that are readily available on Doximity, ACGME, and the programs' websites, to identify further residency program characteristics that could affect the Doximity ranking system. We hypothesized that PD bibliometric values would be positively correlated with program rank.

Materials and Methods

After obtaining study approval through the Advocate Illinois Masonic Medical Center Institutional Review Board committee, we gathered data using the ACGME database of anesthesiology residency programs. We evaluated bibliometric indices using a subscription bibliographic citation database (Scopus; Reed Elsevier, London, United Kingdom), cross-referencing the data with Google Scholar (http://scholar.google.com) and PubMed/National Center for Biotechnology Information (http://www.ncbi.nlm.nih.gov). We reviewed all 2019 PDs' curriculum vitae and biographies available on their respective program's websites for additional data. Finally, we contacted the programs with missing data via e-mail and phone as the final attempt to complete the data.

Bibliometric indices measured for each PD included the following: h-index (the number of publications h that are cited $\geq h$ times),[11-13] total number of publications, and total number of citations. To develop a more holistic picture of each PD, personal characteristics were evaluated, including gender, educational degrees, number and type of fellowships, years of experience posttraining, number of years as a PD, and academic rank within the program. Program characteristics evaluated included program size, number of filled positions, percentage of female and male residents,

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ACGME accreditation date and status, and number of ACGME-approved fellowships. We ranked the PDs' academic ranks hierarchically for analysis (1. Professor, 2. Associate Professor, 3. Assistant Professor, 4. Instructor in medicine, 5. Community-based hospital without ranking system). Program rankings were obtained from the 2019 Doximity standings (ranked by reputation) and divided them into quartiles (Q1-Q4) following the study by Zhang et al.[14] The Doximity reputation ranking is computed based on the results of a survey of more than 53 000 eligible physicians, collecting nominations of the residency programs that in their opinion offer the best clinical training.[14]

Statistical analysis and graphics were produced using R (Vienna, Austria).[15] Chi-square and Student *t* test were used to assess the univariate analysis. Pearson correlation coefficient was computed to assess associations between numeric variables and bibliometric indices. Correlation coefficients (Spearman rho [rs]) were computed to evaluate the association of the variables with the ordinal variables such as hierarchical program rankings or academic rank. A *P* value less than or equal to .05 was considered statistically significant.

Results

We included a total of 152 anesthesiology programs from the 156 ACGME-accredited programs across the United States. Among the 152 PDs, 32% (n = 49) were women and 68% (n = 103) were men; 19% (n = 29) were professors, 29% (n = 44) were associate professors, and 43% (n = 66) were assistant professors. Only 1 of the 152 PDs had no publications. We present the main characteristics of PDs in Table 1. Within the 152 anesthesiology programs, 90.1% (n = 137) had continued ACGME accreditation status, 7.8% (n = 12) had initial accreditation status, 0.7% (n = 1) had continued status with warning, and 1.3% (n = 2) had initial status with warning. A single program, newly accredited, had no filled spots in the year of analysis. We show the main characteristics of programs in Table 2.

Univariate analysis identified baseline differences between the Q1 versus Q2 rank programs in every variable other than PDs' number of fellowships. However, Q2 versus Q3 and Q3 versus Q4 programs had fewer identified baseline differences. Program size, number of filled spots, and the number of ACGME-approved fellowships provided by the programs were the only variables that had a consistent difference between each quartile. In comparing Q1 versus Q4 programs, interestingly, there was no significant difference between PDs' characteristics. Program size, number of filled spots, the number of ACGME-approved fellowships provided by the programs, and the percentage of female residents were the only variables that had a significant difference between Q1 and Q4 programs. Finally, we compared Q1 with all other programs. In this comparison, the h-index of PD as well as program size, number of filled spots, the number of ACGME-approved fellowships provided by the programs, and the percentage of female residents showed a significant difference (Table 3).

Correlation analysis revealed a weak positive correlation of program rank with each of the PDs' bibliometric indices: h-index (rs = 0.18, $P = .02$), total number of publications (rs = 0.25, $P = .002$), and total number of citations (rs = 0.19, $P = .01$). The original ACGME accreditation date (rs = 0.5, $P < .0001$) and female resident percentage in each program (rs = 0.36, $P < .0001$) showed a moderate positive correlation with the program rank. Finally, program rank showed a very strong positive correlation with the program size (rs = 0.77, $P < .0001$) and with the number of ACGME-approved fellowships provided by the program (rs = 0.75, $P < .0001$). In addition, PDs' academic rank, educational degrees, years of experience as a PD, and years of experience posttraining showed no statistically significant correlation with the program rank. However, PDs' years of experience posttraining showed correlation with each of the PDs' bibliometric indices (Table 4). The ratio of female and male PDs in higher and lower ranked groups was not different ($\chi^2 = 1.24$, $P = .26$) and there was no correlation between PDs' sex and the percentage of female residents.

Furthermore, 51% of PDs had no fellowship training, and 2.6% had more than 1 fellowship. Critical care was the most commonly completed fellowship (16.5%), followed by cardiothoracic (12.5%). No significant correlation was found between PDs' number or type of fellowship, and their program's rank or PDs' bibliometric indices. Approximately 14.5% of PDs had a master's degree, and 6.5% had a PhD degree. PDs with a degree other than MD, such as an additional PhD or master's, had a higher academic rank versus PDs with an MD ($P = .02$).

Discussion

In this study, we described characteristics of anesthesiology residency programs and their PDs' bibliometric indices and compared them based on a program's reputation ranking. The purpose of this study was to evaluate the distinguishing characteristics of anesthesiology residency programs with a focus on bibliometric indices of PDs and to investigate how these characteristics affect the Doximity program rank. Our results confirmed the hypothesis that PDs' scholarly activity is positively correlated with program rank. However, the original ACGME accreditation date, female resident percentage in each program, program size, and the number of ACGME-approved fellowships provided by the program showed stronger positive correlation with program rank.

PDs play a crucial role in the competitiveness of the residency selection process and in mentoring the next generation of physicians.[16] With this mandate comes the need to evaluate PDs on their own academic performance. A comprehensive evaluation of academic performance is limited by a lack of quantitative measurements; thus, the assessment of PDs' research productivity remains the central determinant of academic standing. Nevertheless, evaluation of the PDs' research productivity in the field of anesthesiology has been lacking in recent years. As a result, we aimed to investigate the relationship between the research productivity of anesthesiology PDs and the national ranking of their programs.

In contrast to other competitive specialties that traditionally place strong emphasis on research productivity among residency applicants,[5] research productivity has not been an apparent priority within

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anesthesiology for many years. A 2012 study by de Oliveira et al[6] found that the average matched anesthesiology applicant had no peer-reviewed publications, and those with previous research exposure through graduate training were not any more likely to be admitted. Furthermore, research productivity is an expectation of PDs for ACGME-accredited residency training programs, but when compared against those of surgery programs, anesthesiology PDs had considerably less research productivity in terms of peer-reviewed publications and research funding.[3] This is surprising in light of the cultural shift toward a stronger emphasis on research productivity within the most competitive medical specialties, including but not limited to neurosurgery, plastic surgery, and otolaryngology.[13,17,18]

Of note, the Doximity reputation survey does not ask questions concerning the institution or the PD's research productivity. Nevertheless, in this analysis we found that PDs' research productivity is positively correlated with reputation program rank on Doximity. This finding could indicate that reputation is profoundly influenced by research funding; however, funding alone likely does not fully explain this finding. The question, therefore, becomes whether PDs with high research productivity improve the rank of the program or, conversely, if more top-rank programs prioritize research productivity as a quality of the program director more so than other programs. Longitudinal data are further required to solve this chicken-or-egg paradigm.

Despite the limitations, this study represents the first effort within the anesthesiology literature to characterize the relationship between research productivity of a PD with the ranking of their residency program. Studies in other specialties have also used h-index as a measure of research productivity, relating it to academic rank of fellowship and residency programs.[19-21] However, within anesthesiology, the current literature is mostly focused on the characteristics of anesthesiology residency applicants[7-9] and the characteristics of PDs, without an eye toward their research output.[2]

Notably, Culley[3] published a study directly comparing ACGME-accredited anesthesiology and surgery residency programs in terms of their research productivity and success in obtaining National Institutes of Health research funding. In an analogous fashion, this study used h-index as a measure of research productivity, but rather than comparing PDs and their programs against each other, they used this evidence to strengthen their argument that a systemic weakness in anesthesiology research was present.[3] It is important to note that surgery training programs commonly provide up to 1 year dedicated to research for their trainees, yet only a handful of anesthesiology programs have such a privilege. Furthermore, Hindman and Dexter[22] suggested that PDs are undoubtedly influenced by the requirements set by the Residency Review Committee and American Board of Anesthesiology for satisfactory completion of residency and qualification for board examinations; importantly, neither requires formal research productivity. In other words, there is little reason for PDs to prioritize research within their programs. We sought to add much-needed depth to such claims by taking the unique perspective of analyzing the academic history of the PDs.

Another aspect of our study was the analysis of gender and its association to the program rank. To our knowledge, the gender variable has not been explored in-depth within the context of program rank in the anesthesiology literature. However, it has been mentioned frequently, often in relation to faculty ranking and National Institutes of Health funding, within the literature of emergency medicine, surgical oncology, plastic surgery, and many other specialties.[23-25] In particular, we found that the overall percentage of female residents in a program was, in fact, positively correlated with the program rank. Of note, we did not find any correlation between a PD's sex and the ratio of female residents. This curious finding led us to brainstorm a number of possible explanations. Perhaps more established programs with a longer history of clinical and academic excellence are more amenable to recruiting diverse applicants, possibly encouraging diverse applicants to feel more comfortable joining these programs. PDs of higher-ranked programs may also be more willing to break the culture of a male-dominated specialty, for any number of reasons. Finally, it could be that the credentials and personality of the female applicants at higher ranking programs simply aligned better with the goals and culture of the program, although this would be difficult to evaluate without a survey or a copy of the actual application materials. In any case, we believe that the relationship among gender, residency applications, and program rank is one that merits further investigation in future studies.

This study had a few notable limitations. Of the 152 PDs analyzed, up to 10 data points were missing from some of the variables that we collected data on, including the bibliometric indices and percentage of female residents. This was followed by unsuccessful efforts to contact these programs directly for more information. Missing data points were excluded from the analysis, but we did not exclude those programs entirely, so that every other category would have as many data points as available for analysis. Furthermore, the main bibliometric indices we used in this study were h-indices, raw number of publications, and raw number of citations. Although these values are prominently featured among other bibliometric studies, other significant findings may have been achieved with the addition of other validated bibliometric indices in our dataset. For instance, a criticism of the h-index is that it favors highly cited papers in terms of relative importance, and it does not differentiate co-authorship from primary authorship.[26] This may be addressed by using the e-index, which complements the h-index for excess citations.[27] Moreover, although we ranked the PDs' academic ranks hierarchically, we were not able to include and assess slight differences in other categories such as clinical rank designations among them. Finally, some studies have speculated over the validity of Doximity Residency Navigator rankings of residency programs due to the lack of objective and outcomes-based data involved in the ranking protocol.[28,29] However, these speculations do not change the fact that Doximity has been an important tool used by the vast majority of applicants since its release in

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2014, with 1 multispecialty survey study by Smith et al.[30] finding that Doximity reputation rankings greatly influenced the application, interview choice, and match list rankings of most applicants to their institution.

In light of these limitations, in this pilot study, we thoroughly assessed the relationship between the reputation ranking of anesthesiology residency program with the academic credentials and demographics of PDs as well as program characteristics. Although this was a pilot study, it may pave the way to enlighten future studies on the changing academic culture of anesthesiology.

Conclusion

We described characteristics of anesthesiology residency programs and their PDs' bibliometric indices and compared them based on a program's reputation ranking. In this study, we found that reputation-based program ranking in the growing field of anesthesiology is positively correlated with program size, female resident percentage, ACGME approval date, number of ACGME-approved fellowships, and PDs' research productivity.

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Abstract

Background: Program directors (PDs) play a crucial role in the competitiveness of the residency selection process and in mentoring the next generation of physicians. With this mandate comes the need to evaluate PDs on their own academic performance. We aimed to evaluate the distinguishing characteristics of anesthesiology residency programs with a focus on academic productivity of PDs and to investigate how these characteristics affect the Doximity program rank.

Methods: We identified anesthesiology program rankings from 2019 Doximity standings and divided them into quartiles (Q1-Q4). PD academic history and bibliometric indices (H-index, number of publications and citations) were collected through program websites, PubMed, Scopus, Google Scholar, and Accreditation Council for Graduate Medical Education (ACGME) websites.

Results: A total of 152 active anesthesiology programs and PDs were identified across the United States. Among the 152 PDs, 32% (n = 49) were women and 68% (n = 103) were men. There were differences between the Q1 versus Q2 programs in all of the variables other than PDs' number of fellowships. However, Q2 versus Q3 and Q3 versus Q4 programs had fewer identified differences. Each of the assessed PDs' bibliometric indices showed weak correlation with the program rank; however, there were stronger correlated factors of program rank, such as the program's original ACGME accreditation date (rs = 0.5, $P < .0001$) and female resident percentage (rs = 0.36, $P < .0001$) with moderate positive correlation. Additionally, the program size (rs = 0.77, $P < .0001$) and the number of ACGME-approved fellowships provided by the program (rs = 0.75, $P < .0001$) had a very strong positive correlation.

Conclusion: This study shows that program rank in the growing field of anesthesiology correlates with program size, female residents' percentage, ACGME approval date, number of ACGME-approved fellowships, as well as PDs' research productivity.

Keywords: Anesthesiology, residency, fellowship, publications, academic performance

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Tables

Table 1. *Anesthesiology Program Director Characteristics*

Characteristics (n = 152)	Mean ± SD (Range)
h-index	5.7 ± 7.42 (0-42)
No. of peer-reviewed publications	20 ± 55.8 (0-614)
No. of citations	352.5 ± 869.5 (0-5704)
Experience posttraining, y	14.5 ± 8.5 (2-43)
Experience as the program director, y	5 ± 4.2 (0-23)
No. of fellowships	0.5 ± 0.5 (0-2)

Table 2. *Anesthesiology Residency Programs Characteristics*

Characteristics (n = 152)	Mean ± SD (Range)
Original ACGME accreditation date	1974 ± 22.8 (1946-2018)
No. of ACGME-approved fellowships	2.3 ± 2.1 (0-7)
Program size (No. of available residency spots)	47.8 ± 28.8 (5-128)
Filled spots (No. of residents in the program)	42.7 ± 26.3 (0-114)
Percentage of female residents	30.8 ± 12.8 (0-63)

Abbreviation: ACGME, Accreditation Council of Graduate Medical Education.

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Tables *continued*

Table 3. *Comparing Characteristics of Q1, Q2, Q3, and Q4 Programs and Program Directors (PD)*

Variable	Q1, Mean ± SD n = 38	Q2, Mean ± SD n = 38	Q3, Mean ± SD n = 38	Q4, Mean ± SD n = 38	*P* Value, Q1 vs Q2	*P* Value, Q2 vs Q3	*P* value, Q3 vs Q4	*P* Value, Q1 vs Q4	*P* Value, Q1 vs All Other
h-index of PD	8.05 ± 9.1	3.87 ± 4.6	4.78 ± 6.0	5.96 ± 8.7	.01[a]	.46	.51	.33	.05[a]
PD's No. of citations	563.23 ± 1132.7	155.60 ± 396.2	252.75 ± 619.0	432.84 ± 1083.4	.04[a]	.42	.41	.62	.15
PD's No. of publications	25.02 ± 33.5	10.80 ± 16.7	12.81 ± 17.8	32.68 ± 108.6	.02[a]	.62	.31	.70	.40
Experience as PD, y	6.07 ± 4.9	4.00 ± 3.3	5.31 ± 4.1	4.42 ± 4.2	.03[a]	.13	.36	.50	.09
PD's experience posttraining, y	15.39 ± 8.0	11.60 ± 6.1	15.10 ± 9.1	15.80 ± 10.1	.02[a]	.05[a]	.76	.81	.41
PD's No. of fellowships	0.54 ± 0.5	0.42 ± 0.5	0.57 ± 0.5	0.47 ± 0.5	.33	.19	.41	.60	.63
Program size	80.50 ± 24.5	53.71 ± 23.5	35.13 ± 11.3	22.13 ± 11.8	<.0001[b]	<.0001[b]	<.0001[b]	<.0001[b]	<.0001[b]
Filled spots	72.39 ± 20.5	48.94 ± 20.9	31.52 ± 10.8	18.07 ± 11.9	<.0001[b]	<.0001[b]	<.0001[b]	<.0001[b]	<.0001[b]
Percentage of female residents	36.65 ± 7.9	31.84 ± 9.0	29.25 ± 11.0	24.04 ± 18.9	.01[a]	.28	.18	.001[a]	<.0001[b]
No. of ACGME-approved fellowships	4.76 ± 1.4	2.65 ± 1.6	1.34 ± 1.4	0.48 ± 0.8	<.0001[b]	<.0001[b]	.002[a]	<.0001[b]	<.0001[b]

Abbreviations: ACGME, Accreditation Council of Graduate Medical Education.

[a]$P \leq .05$.

[b]$P < .0001$.

Table 4. *Correlation Analysis of Program Directors' Years of Experience Posttraining and Bibliometric Indices*

Bibliometric indices	Correlation (r)	95% Confidence Interval	*P* Value
h-index	0.41	0.26-0.54	<.0001[b]
No. of publications	0.17	0.01-0.33	.03[a]
No. of citations	0.33	0.17-0.47	<.0001[b]

[a]$P \leq .05$.

[b]$P < .0001$.