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Factors Associated with Early Career Research Productivity after Ophthalmology Residency

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Abstract

Background Few studies have evaluated associations between ophthalmology trainee characteristics and performance with postgraduate research productivity.

Purpose This article evaluates factors associated with post-residency research productivity among U.S. ophthalmology graduates.

Methods Publicly available information of residents graduating between 2009 and 2014 from 30 randomly selected U.S. ophthalmology programs was collected from June to September 2020. Differences in publications between the 5 years post-residency and pre-residency/residency period were used as metrics of productivity. Residents with incomplete records were excluded.

Results A total of 758 of 768 residents, 306 females (40.4%) and 452 males (59.6%), met inclusion criteria. The mean (standard deviation [SD]) number of pre-residency publications was 1.7 (4.0), residency was 1.3 (2.2), and post-residency was 4.0 (7.3). Mean (SD) H-index was 4.2 (4.9). Top-ranked residency ($p = 0.001$), Alpha Omega Alpha (AOA) medical honor status ($p = 0.002$), U.S. medical school graduates ($p < 0.001$), and academic career ($p < 0.001$) were all associated with higher pre-/post-residency mean publication difference. Pursuing fellowship training also was associated with higher total publications ($p < 0.001$). Of all pre-residency degrees, PhD had the greatest odds of high postgraduate publications (defined as > 4). There was a positive correlation between both pre-residency/residency and post-residency publications (rho $= 0.441$; $p < 0.001$) and between mean difference of pre-residency/post-residency publications for residents at a program and that program's Doximity rank (rho $= 0.497$; $p < 0.001$).

Keywords
- ophthalmology
- residency
- publication
- research productivity
- Doximity rank

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Multivariate logistic regression revealed, academic career choice (odds ratio [OR] = 3.38; $p < 0.001$), Heed fellowship (OR = 3.12; $p = 0.031$), > 2 residency publications (OR = 2.89; $p < 0.001$), AOA status (OR = 2.0; $p = 0.004$), and top-ranked residency programs (OR = 1.89; $p = 0.007$), had greatest odds of > 4 postgraduation publications.

Conclusion Higher post-residency productivity was associated with multiple factors, with choice of an academic career, Heed fellowship, and residency productivity playing key roles.

There are many factors that influence the selection of an applicant for residency. These include performance on standardized testing, medical school rank, clinical clerkship grades, and research activity.[1] Publications and research conducted prior to entering residency are often viewed favorably by admission committees as evidence of commitment and genuine interest in the field.[2] However, the current criteria used to select residents for ophthalmology residency has been brought into question, with some stating that the current selection process fails to consistently predict future performance during residency.[3] Moreover, few studies in the ophthalmic literature have evaluated the relationship between pre-residency/residency performance and future career productivity and achievement. One such study conducted by Cruz et al looked at graduates of Wilmer's ophthalmology residency program and found a positive association between number of pre-residency research publications and academic productivity score, a score that accounted for activities important to becoming a successful physician scientist.[4] However, this study evaluated 51 residents from one residency program and the findings are not necessarily generalizable to the whole field of ophthalmology.

Studies in the general medical literature and other non-ophthalmology subspecialties of surgery have attempted to answer this question regarding research productivity. For example, an otolaryngology report found that medical students who publish at least one paper before residency are nearly six times more likely to publish during otolaryngology residency than those who did not.[5] As for research during residency, Prasad et al looked at whether internal medicine residents' publications record predicted future publications during and after fellowship. They found that publications at the time of fellowship application submission was a poor predictor of future publication productivity.[6] To the contrary, a retrospective longitudinal study of radiology residents over a 30-year period, at one institution, found that pre-residency publication volume positively correlated with future publications, funding status with the National Institutes of Health (NIH), and Hirsch index (H-index), a measure of both quantity and quality of articles produced by considering citations.[2] Also, the authors of this study found that research experience in medical school was associated with a greater number of publications within 5 years of graduation.[7] Likewise, a study evaluating neurology residents demonstrated that both pre-residency and residency publications were associated with higher post-residency publications.[8] Finally, a study of urology residents revealed that publications during training as well as pursuing fellowship training, and pursuing an academic career positively correlated with early career publications.[9]

Ophthalmic studies addressing postgraduation research productivity are limited and focused on single institutions and reports in the nonophthalmic literature have yielded disparate results. Thus, we sought to evaluate the association between pregraduation factors likely to be predictive of early-career, post-residency publications among ophthalmology residents training at various residency programs in the United States.

Methods

Study Population

A retrospective review of all graduates from a random sample of United States ophthalmology residency programs between 2009 and 2014 was conducted. Thirty ophthalmology residency programs were randomly selected from the top 100 programs according to the 2019 Doximity rankings of ophthalmology programs. All information for this study was acquired from the public domain. Resident graduate lists were created for the years 2009 to 2014 from residency program Web sites and Doximity. Publicly available information on each of the graduates, including undergraduate university, medical school, other graduate degrees (e.g., PhD), fellowship subspecialties completed, Alpha Omega Alpha (AOA) Honor Medical Society membership, Heed Ophthalmic Foundation Fellowship, and academic versus nonacademic career choice was collected from Doximity and professional Web sites. PubMed search engine[10] then was used to search the number and type of publications (clinical vs. bench) for each graduate. Finally, each graduate's H-index was collected from the Scopus database.[11]

Randomization

Research Randomizer, a free Web site, was used for randomization.[12] One set was generated with 30 randomly chosen unique numbers from 1 to 100. The 30 programs with the rank matching the random sample of numbers were included in the study group. The randomization scheme is outlined in ►**Fig. 1**.

Publication Data

PubMed was searched for each graduate resident using multiple permutations including the graduate's (1) full

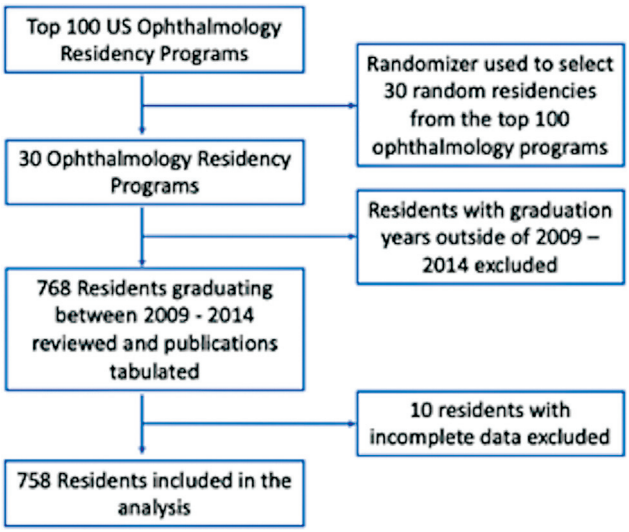

Fig. 1 Randomization process with inclusion and exclusion criteria.

name with middle initial, (2) first and last name only, and (3) first and last name plus "Ophthalmology." Additionally, any graduates with maiden names were searched using both names. The unique results of the three search terms then were combined to comprise the publication list. Each graduate's publication list was then reviewed, and number of publications recorded and categorized by date of publication. Any publication occurring prior to and including December 31 of the year in which the graduate began ophthalmology residency was considered to have been published prior to residency. For example, if a resident began residency in 2011 any paper published prior to and including December 31st, 2011, was considered a pre-residency publication. All publications ending December 31 of their residency graduation year were considered to have been published during residency. Finally, the same adjustment was made for fellowship with all publications categorized as occurring during fellowship if they were published by December 31st of the fellowship completion year. Although it is known that residencies and fellowships run from July to July, this adjustment was made as it was considered likely that publications occurring in the 6 months immediately following residency and fellowship would be attributable to work completed during those respective training programs and not new work created after completion of the program.

Publications were only included if they occurred prior to residency, during residency, or 5 years after graduating residency. Publications during the 5 years post-residency were categorized into fellowship, post-fellowship, or post-training based on pursuance of fellowship training. Any publications occurring after this 5-year time point were excluded from consideration. Additionally, publications were only attributed to a graduate if the publication was affiliated with an institution where the graduate spent professional time. Authorship was recognized for any attribution within the author list of a publication, regardless of the order of authors. Differences in publications, termed publication difference, between the 5 years post-residency and those completed prior to and during residency were used as metrics of productivity. High postgraduate productivity was defined as more than four (>4) publications which was found to be the average number of post-residency publications. Top-ranked residency programs were defined as the top 50% of the randomly selected programs.

H-Index

The H-index was accessed using the Scopus database[11] and was used as a measure of overall academic achievement of each graduate. The H-index is defined as the number of publications by an author (H) that have been cited a minimum of H times. The index therefore assesses the quantity and qualitative impact of those publications. As an example, a graduate with an H-index of 10 has at least 10 publications, each of which has been cited at least 10 times. Any publications that have been cited fewer than 10 times are not counted.

Exclusion Criteria

Any graduates who switched residencies or whose postgraduate activities through the 5-year post-residency time point could not be verified were excluded from consideration. Any residents with incomplete data were also excluded.

Statistical Analysis

Deidentified tabulated data were analyzed. The mean, median, standard deviation (SD), and interquartile range (IQR) were calculated for all continuous variables. These variables were divided into categories for analysis. Statistical analysis and associations among variables was performed using two-tailed Student's *t* and chi-square tests, univariate and multivariate logistic regression, and odds ratio (OR) and Pearson's correlation coefficient calculations with STATA-14 software (Stata Corp LP, College Station, TX). Graphs and tables were constructed using STATA-14, and Microsoft Excel and Word software (Microsoft Corp, Redmond, WA). Significance was set at $p<0.05$.

Results

Seven hundred fifty-eight of 768 residents met inclusion criteria for analysis. There were 306 females (40.4%) and 452 males (59.6%). Five hundred eighty-three (76.9%) pursued fellowship training after completing residency whereas 175 (23.1%) went directly into practice. The mean (SD) number of pre-residency publications was 1.7 (4.0). Residency publications, 1.3 (2.2) and post-residency publications were 4.0 (7.3). The mean (SD) number of total publications was 7.0 (10.6). The mean (SD) H-index was 4.2 (4.9) (►**Table 1**).

There were significantly more AOA members in top-tier residencies than in the lower 50% programs (142 vs. 66; $p<0.001$). This difference was similarly noted for the number of Heed fellows (31 vs. 3; $p<0.001$). Factors associated with significantly higher pre-/post-residency mean publication difference included graduating from a top rank residency ($p=0.001$), being inducted into the AOA Honor Medical Society ($p=0.002$), being a U.S. medical school graduate

Table 1 Baseline characteristics of residents graduating (2009–2014) and their publications

Characteristic	Mean ± SD or *N* (%)	Range
Sex		
Male	452 (59.6)	
Female	306 (40.4)	
Fellowship	583 (76.9)	
No fellowship	175 (23.1)	
AOA	208 (27.4)	
Non-AOA	550 (72.6)	
Heed fellow	34 (4.5)	
Non-Heed	724 (95.5)	
U.S. graduates	731 (96.4)	
FMG	27 (3.6)	
Academic	182 (24.0)	
Nonacademic	547 (72.2)	
Other (e.g., industry, hybrid)	29 (3.8)	
Pre-residency publications	1.7 ± 4.0	0–67
Residency publications	1.3 ± 2.2	0–25
Post-residency publications	4.0 ± 7.3	0–72
Total publications	7.0 ± 10.6	0–111
H-index	4.2 ± 4.9	0–55

Abbreviations: AOA, Alpha Omega Alpha; FMG, foreign medical graduate; H-index, Hirsch index; SD, standard deviation.

($p < 0.001$), and pursuing an academic career after training ($p < 0.001$) (►**Table 2**).

Additionally, pursuing fellowship training was associated with higher total publications ($p < 0.001$). The mean (SD) pre--residency/residency publications among those not pursuing fellowship were 2.2 (4.5) and their post-residency publication number was 0.5 (1.2). The mean (SD) pre-residency/residency publications among those pursuing fellowship were 3.3 (5.3) ($p = 0.013$) and the mean (SD) number of post-fellowship publications was 3.2 (5.4) ($p < 0.001$). Those who pursued fellowship and chose academic careers had more post-fellowship publications, 6.2 (7.7) than those choosing nonacademic careers, 1.9 (3.3) ($p < 0.001$). We performed analysis of variance using the mean (SD) and median (IQR) of both pre-residency/residency publications as well as fellowship and post-fellowship publications for each subspecialty. The results are detailed in ►**Table 3**. There was a significant difference between both pre-residency/residency publications ($p = 0.017$) and fellowship and post-fellowship publications ($p < 0.001$) among the different ophthalmology subspecialties.

Of all fellowships, oncology had the highest odds of greater-than-average publications, whereas pursuing a non-American Society of Ophthalmic Plastic and Reconstructive Surgery-accredited oculoplastic fellowship or cornea fellowship were associated with the lowest odds of greater-than-average publications (►**Table 4**). Compared with all other pre-residency degrees, PhD had the greatest odds of high postgraduate publications (defined as > 4) (►**Table 5**). However, on multivariate logistic regression analysis, having a PhD did not have significantly greater odds of greater-than-

Table 2 Comparison of mean publication difference among various groups

Characteristic	Mean pre-residency publications	Mean post-residency publications	Mean publication difference ± SD	95% CI	*p*-Value	Number (%) with > 4 postgraduation publications
Male (*N* = 452)	3.3 (5.9)	4.4 (8.0)	1.1 ± 7.5	0.4–1.8	0.460	124 (27.4)
Female (*N* = 306)	2.6 (3.6)	3.3 (5.8)	0.7 ± 5.7	0.1–1.4		67 (21.9)
AOA (*N* = 208)	3.0 (4.3)	5.2 (8.6)	2.2 ± 8.3	1.1–3.4	**0.002**	70 (33.6)
Non-AOA (*N* = 549)	3.0 (5.4)	3.5 (6.6)	0.5 ± 6.2	0.0–1.0		121 (22.0)
Heed fellow (*N* = 34)	9.6 (5.9)	12.8 (10.9)	3.2 ± 9.3	−0.1 to 6.4	0.054	25 (73.5)
Non-Heed (*N* = 723)	2.7 (4.9)	3.5 (6.7)	0.9 ± 6.7	0.4–1.3		166 (22.9)
FMG (*N* = 27)	12.4 (16.5)	5.9 (10.2)	−6.5 ± 10.5	−10.7 to −2.4	< **0.001**	10 (37.0)
U.S. graduate (*N* = 731)	2.6 (3.8)	3.9 (7.1)	1.2 ± 6.5	0.8–1.7		181 (24.7)
Academic career (*N* = 182)	4.7 (7.8)	8.3 (10.5)	3.6 ± 10.0	2.2–5.1	< **0.001**	85 (46.7)
Nonacademic career (*N* = 547)	2.4 (3.8)	2.4 (4.6)	0.0 ± 4.9	−0.5 to 0.4		95 (17.3)
PhD (*N* = 35)	8.7 (6.2)	8.1 (9.2)	−0.7 ± 9.5	−3.9–2.6	0.154	18 (51.4)
No PhD (*N* = 723)	2.7 (4.9)	3.8 (7.1)	1.0 ± 6.7	0.5–1.5		173 (23.9)
Lower ranked residency (*N* = 403)	1.8 (3.7)	1.9 (3.9)	0.1 ± 4.4	−0.3–0.6	**0.001**	50 (14.0)
Top-ranked residency (*N* = 355)	4.0 (5.9)	5.7 (8.9)	1.7 ± 8.4	0.9–2.5		141 (34.9)

Abbreviations: AOA, Alpha Omega Alpha Honor Society; CI, confidence interval; FMG, foreign medical graduate; H-index, Hirsch index; PhD, Doctor of Philosophy; SD, standard deviation.
Note: Bold *p*-values indicate statistical significance.

Table 3 ANOVA (analysis of variance) comparison of mean and median publications by fellowship subspecialty

Characteristic	ASOPRS	Combined/ Other	Cornea	Glaucoma	Medical retina	Neuro-ophthalmology	Non-ASOPRS oculoplastic	Oncology	Pediatric ophthalmology	Refractive	Surgical retina	Uveitis	*p*-Value
Number (*n*)	44	16	124	94	27	18	15	14	54	5	151	21	
Pre-/residency mean (SD) publication	2.8 (2.8)	7.2 (17.9)	2.7 (5.8)	3.0 (4.3)	2.1 (2.0)	3.7 (3.8)	2.2 (2.3)	5.7 (5.1)	2.1 (2.5)	1.4 (1.1)	4.2 (4.6)	3.5 (4.0)	0.017
Pre-/residency median (IQR) publication	2 (1, 4)	3.5 (0, 5)	1 (0, 3)	2 (0, 4)	1 (0,4)	3 (1, 5)	2 (0, 3)	5 (2, 7)	2 (0, 3)	1 (1, 2)	3 (1, 6)	2 (1, 5)	0.001
Fellowship/ post-fellowship mean (SD) publication	6.0 (5.5)	9.0 (12.5)	2.3 (3.7)	3.5 (6.4)	3.0 (4.5)	4.3 (5.4)	2.6 (4.3)	15.0 (12.1)	3.5 (5.0)	1 (1)	7.8 (10.4)	6 (9.3)	< 0.001
Fellowship/ post-fellowship median (IQR) publication	4 (1.5, 9.5)	5 (1, 9.5)	1 (0, 3)	1 (0, 3)	1 (0,4)	2.5 (0, 7)	1 (0, 4)	14 (5, 22)	2 (1, 4)	1 (0, 2)	4 (1, 10)	1 (0, 7)	< 0.001
% with > 4 post-residency publications	47.7	81.3	12.9	18.1	14.8	38.9	13.3	50.0	22.2	0	49.0	42.9	

Abbreviations: ASOPRS, American Society of Ophthalmic Plastic and Reconstructive Surgery; IQR, interquartile range; SD, standard deviation.

Table 4 Logistic regression summary of association of fellowship with high publication

Fellowship type	Odds ratio	Standard error	95% CI	*p*-Value
ASOPRS oculoplastic	Reference	–	–	–
Combined/Other	1.444	0.847	0.458–4.560	0.531
Cornea	0.347	0.132	0.164–0.732	**0.006**
Glaucoma	0.523	0.202	0.246–1.114	0.093
Medical retina	0.413	0.229	0.139–1.225	0.111
Neuro	0.919	0.526	0.299–2.823	0.883
Non-ASOPRS oculoplastic	0.222	0.182	0.045–1.107	0.066
Oncology	8.667	7.133	1.727–43.491	**0.009**
Pediatrics	0.506	0.221	0.215–1.189	0.118
Refractive	1	(empty)		
Retina	1.464	0.508	0.741–2.890	0.272
Uveitis	1.083	0.582	0.378–3.104	0.882

Abbreviations: ASOPRS, American Society of Oculoplastic and Reconstructive Surgeons; CI, confidence interval.
Note: High publications were defined as > 4 publications.
Note: Bold *p*-values indicate statistical significance.

Table 5 Multivariate logistic regression of association of pre-residency degree and high post-residency publications

	Odds ratio	Standard error	95% CI	*p*-Value
MPH	Reference	–	–	–
Other Master's	0.2	0.2	0–1.2	0.080
Other	0.4	0.3	0.1–1.5	0.175
PhD	5.3	3.7	1.4–20.5	**0.015**
Research fellow	1.3	1.0	0.3–5.9	0.705
Other fellowship	1.2	0.8	0.3–4.5	0.739

Abbreviations: CI, confidence interval; MPH, Master's in Public Health; PhD, Doctor of Philosophy.
Note: Residents with pre-residency PhD had the greatest odds of high post-graduations productivity defined as > 4 publications.
Bold *p*-values indicate statistical significance.

Table 6 Multivariate logistic regression analysis of high post-residency publications

	Odds ratio	Standard error	95% CI	*p*-Value
AOA membership	2.001	0.486	1.244–3.220	**0.004**
Heed fellow	3.124	1.648	1.111–8.787	**0.031**
Academic career	3.382	0.826	2.095–5.460	< **0.001**
Top-ranked programs	1.897	0.450	1.192–3.021	**0.007**
PhD	1.751	0.918	0.627–4.894	0.285
Gender, male	1.160	0.286	0.715–1.882	0.547
Residency publication > 2	2.893	0.753	1.737–4.817	< **0.001**
Pre-residency publication > 2	1.338	0.400	0.745–2.405	0.329

Abbreviations: AOA, Alpha Omega Alpha Honor Society; CI, confidence interval; PhD, Doctor of Philosophy.
Note: High publications were defined as > 4 publications.
Bold p-values indicate statistical significance.

average postgraduate publications compared with other factors (►**Table 6**). Doing a pre-residency research fellowship or other pre-residency fellowship also were not associated with increased odds of greater-than-average post-residency publications (►**Table 5**).

There was a positive correlation between pre-residency/residency and post-residency publications (rho = 0.441; $p < 0.001$) (►**Fig. 2**) as well as a positive correlation between the mean difference of pre-residency/post-residency publications for residents at a program and that program's ranking

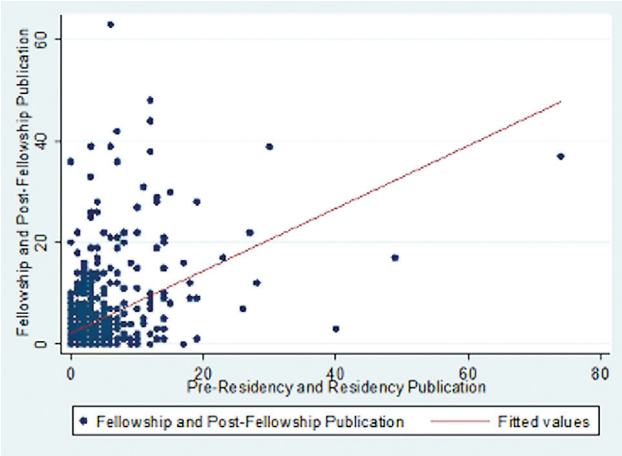

Fig. 2 Correlation between pre-residency and residency publications and fellowship and post-fellowship publications. There was a positive correlation between pre-residency and residency publications and postgraduations productivity.

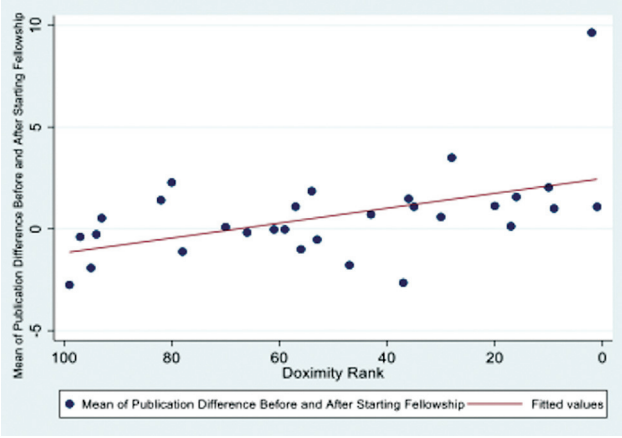

Fig. 3 Residency program Doximity rank versus mean difference of pre- and post-residency publications. Increased research productivity positively correlated with higher ranked residency programs.

(rho = 0.497; $p < 0.001$) (►**Fig. 3**). There also was a positive correlation between pre-residency and residency publications and post-residency graduation productivity. Multivariate logistic regression analysis revealed, in order, that pursuing an academic career (OR = 3.38; $p < 0.001$), being a Heed fellow (OR = 3.12; $p = 0.031$), having > 2 residency publications (OR = 2.89; $p < 0.001$), AOA status (OR = 2.0; $p = 0.004$), and graduating from a top-rank residency (OR = 1.89; $p = 0.007$) had the greatest odds of greater-than-average (> 4) postgraduation publications (►**Table 6**).

Discussion

In this retrospective analysis, pre-residency/residency factors associated with early career research productivity were evaluated. Our study found several factors positively correlated with greater-than-average post-residency publications. Several of these factors including AOA membership and pursuit of an academic career have previously been reported in other populations.[9,13] This study established new associations including obtaining a Heed fellowship, attending a top-ranking residency, and publishing greater than two papers during residency.

Previous literature from several smaller studies concerning the importance of pre-residency publications in predicting future research productivity reported a positive correlation between pre-medical/medical school publications and early career academic productivity.[2,4,8]

This association seems reasonable, as these students get early exposure to research, learning how to perform research and establishing research connections which may continue into their careers. Although there was a trend to more publications in this group, the current study did not find this association to be significant. It is possible that this difference is due to a higher percentage of physicians in the current study going into nonacademic practice compared with prior studies.

Results of previous studies assessing the predictive value of a PhD regarding further research productivity have been mixed. Cruz et al studied a small group of ophthalmology residents at a single institution and demonstrated no statistically significant association between publications during a PhD and early career productivity as measured by academic productivity score[4] and higher than average post-residency publications. However, another cohort study of neurology residents found contrasting results and a PhD was associated with higher post-residency publication scores.[8] These findings comport with our study finding that residents with a PhD were more likely to have greater-than-average productivity (►**Table 5**). However, when compared with other factors, its impact was relatively minimal (►**Table 6**). Although our findings are derived from a larger and possibly more representative sample, these disparate findings call into question the utility of evaluating ophthalmology applicants based on pre-residency publications as well as publications completed during dedicated research years as a predictive tool for future research productivity. The need to reevaluate the merits of pre-residency publications is bolstered further by a study among ophthalmology applicants that revealed that up to 9.2% of applicants had at least one unverifiable publication on their application.[14] Furthermore, a study among Canadians applying for residency in a single surgical subspecialty found that 23% of applicants claiming publications had at least one misrepresented publication.[15]

Another important finding of this study is the demonstration of a relationship between research productivity and career pursuits. We found that pursuing fellowship training or pursuing an academic career were associated with higher total publications and higher odds of greater-than-average postgraduate publications, respectively. This is consistent with a study of urology residents that found a significantly positive correlation between research productivity after residency and pursuit of fellowship training as well as pursuit of an academic career.[9] These associations are logical in that a component of the job responsibilities in academia often is to perform research, which often is tied to promotions and funding. Additionally, the correlation between pursuing fellowship and greater pre-residency/residency

publications is logical given the incentive to improve one's application for fellowship. However, it is worth noting that this increase in productivity continued even after fellowship regardless of whether or not they pursued academics. Thus, assessing an applicant's plans post-residency may assist in predicting future research productivity.

Regarding AOA membership, Heed fellowship, and top-ranking residency program, the present study found that these three factors were associated with greatest odds of high post-residency productivity. The Heed fellowship is a grant to pursue research during fellowship and requires a commitment of 20% of one's time to research. Thus, the association of increased productivity with Heed fellowship is understandable. Similarly, those in top-ranking residencies likely have increased access and exposure to research projects, as many of these programs are affiliated with medical schools that rank highly and may have established NIH or other funding sources. Although AOA membership does not have a research requirement, there is significant overlap between those elected to AOA and those in top-ranking residency programs, that may contribute partly to this association. Indeed, this study demonstrated that both AOA members and Heed fellows were significantly clustered in the higher-tier residency programs.

This study found no statistically significant difference between male and female residents regarding publication difference. This contrasts with the neurology resident study referenced above, which found a difference in publications by sex with males having more publications than females both before, during, and after residency.[8] The difference with our findings may have been influenced by the proportion of graduates in academic positions (88% compared with 24% in this study) and that fewer female neurology residents had a PhD compared with male residents.

There are several limitations to this study, not least of which is the retrospective design. The veracity of our findings is dependent on the accuracy of documentation within the databases we used. Also, we limited our publication lists to PubMed searchable publications. As some peer-reviewed journals are indexed in other academic search engines, this may have underestimated the total number of publications for some residents. Additionally, possible confounding factors that may affect resident research productivity exist and were not assessed. These include permitting dedicated research time,[9] the institution of an 80-hour work week,[16] and the presence of a monetary reward system for research output. These have all been associated with a significant increase in research productivity among residents.[17] Despite these limitations, our study had several important strengths, including the large sample size of residents from 30 different U.S. ophthalmology programs with representation from each geographic area. Based on our review of PubMed and Google Scholar databases, this is the largest study, to date, to assess research productivity prior to, during, and after residency as well as evaluating the relative strength of association of factors impacting post-residency productivity.

Conclusions

Higher post-residency productivity was associated with multiple factors with choice of an academic career, Heed fellowship, and residency productivity playing key roles. These factors may be useful for residency and fellowship programs interested in selecting candidates for their programs who are likely to have high postgraduate research productivity.

Conflict of Interest
None declared.

References

1 Nallasamy S, Uhler T, Nallasamy N, Tapino PJ, Volpe NJ. Ophthalmology resident selection: current trends in selection criteria and improving the process. Ophthalmology 2010;117(05):1041–1047
2 Rezek I, McDonald RJ, Kallmes DF. Pre-residency publication rate strongly predicts future academic radiology potential. Acad Radiol 2012;19(05):632–634
3 Lee AG, Golnik KC, Oetting TA, et al. Re-engineering the resident applicant selection process in ophthalmology: a literature review and recommendations for improvement. Surv Ophthalmol 2008; 53(02):164–176
4 Cruz FM, Wang J, Joseph SS, Miller NR. Subject and academic setting of pre-residency publications as potential predictors of post-residency academic productivity in a cohort of ophthalmology residents. J Acad Ophthalmol 2018;10:16–22
5 Kohlert S, Zuccaro L, McLean L, Macdonald K. Does medical school research productivity predict a resident's research productivity during residency? J Otolaryngol Head Neck Surg 2017;46(01):34
6 Prasad V, Rho J, Selvaraj S, Cheung M, Vandross A, Ho N. Can a resident's publication record predict fellowship publications? PLoS One 2014;9(03):e90140
7 Brancati FL, Mead LA, Levine DM, Martin D, Margolis S, Klag MJ. Early predictors of career achievement in academic medicine. JAMA 1992;267(10):1372–1376
8 Dorsey ER, Raphael BA, Balcer LJ, Galetta SL. Predictors of future publication record and academic rank in a cohort of neurology residents. Neurology 2006;67(08):1335–1337
9 Yang G, Zaid UB, Erickson BA, Blaschko SD, Carroll PR, Breyer BN. Urology resident publication output and its relationship to future academic achievement. J Urol 2011;185(02):642–646
10 PubMed Accessed between June 1 and November 30, 2020, at: https://pubmed.ncbi.nlm.nih.gov/
11 Scopus Database Accessed between June 1 and August 30, 2020, at: https://www.scopus.com/
12 Research Randomizer Accessed June 1, 2020, at: https://www.randomizer.org/
13 Shan SJC, Wang J, West-Gower E, Miller NR. Pre-residency characteristics associated with post-residency academic productivity in a cohort of ophthalmology residents. J Acad Ophthalmol 2012;5:24–36
14 Tamez HM, Tauscher R, Brown EN, Wayman L, Mawn LA. Rate of unverifiable publications among ophthalmology residency applicants invited to interview. JAMA Ophthalmol 2018;136(06):630–635
15 Sater L, Schwartz JS, Coupland S, Young M, Nguyen LH. Nationwide study of publication misrepresentation in applicants to residency. Med Educ 2015;49(06):601–611
16 Levy DM, Luchetti TJ, Levine BR. Have residents produced more research since the inception of the 80-hour workweek? Iowa Orthop J 2017;37:205–209
17 Chang CW, Mills JC. Effects of a reward system on resident research productivity. JAMA Otolaryngol Head Neck Surg 2013; 139(12):1285–1290