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Predictive Factor of Preresidency Publication on Career Academic Achievement in Urologists.



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**Title**: Predictive Factor of Pre-Residency Publication on Career Academic Achievement in Urologists

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**Abstract**

Introduction: Publications at any point in training can impact future academic interest and achievement. Implications of publishing scholarly work prior to residency on accomplishments during and after residency are under-studied.

Methods: We obtained publication output before, during, and after residency for urologists graduating between 2002 and 2008 from the 36 training programs affiliated with a top 50 urology hospital nationwide. Additional collected information included fellowship training, current appointment, total and R01 National Institutes of Health (NIH) grants, and h-index. We compared urologists' pre-residency scholarship with residency and career achievements.

Results: We retrieved data from 543 urologists, of whom 161 (29.7%) and 92 (16.9%) published one or more total and first author manuscripts before residency, respectively. A total of 269 (49.5%) urologists went on to pursue fellowship and 183 (33.7%) entered academic practice. Urologists with a first author publication before residency had increased odds of entering academics (OR: 1.9, 95% CI: 1.2-3.1), obtaining NIH grants (OR: 2.2, 95% CI: 1.1-4.3), and acquiring NIH R01 grants (OR: 4.1, 95% CI: 1.7-9.7). Those with more first author manuscripts prior to residency were also more likely to pursue fellowship (p=**0.0002**), have a higher h-index (p<**0.0001**), and publish more during (p<**0.0001**) and after residency (p=**0.0002**). Those with more total publications before residency, however, were only associated with greater h-index (p=**0.002**) and publications in residency (p=**0.001**).

Conclusions: Pre-residency scholarly endeavors, particularly first author publications, are associated with future scholarly achievement, which may inform both resident selection procedures and medical education curricular development.

## Introduction

Medical students engaging in research make more informed career choices, improve their short and long-term scientific productivity, and gain favorable attitudes towards research.[1–3] Scholarly activity can promote fluency in evidence-based medicine and encourage critical thinking development, key attributes to becoming an effective clinician and to lifelong learning.[4,5] Engaging in the scientific process and publishing as a medical student may lead to entry into more competitive residencies and cultivate interest in a future academic career.[6–9]

Although early career research and publications may positively associate with academic interest and achievement,[10–13] career implications of pre-residency publication output are unclear. In a study of 949 neurosurgeons, an academic career was not associated with publications before residency;[14] another group found that publications before residency had no statistically significant effect on residency publication or fellowship pursuit.[15] A study in radiation oncology residents, however, demonstrated that academic careers were twice as likely in residents with one pre-residency publication compared to those with none.[16] Moreover, Hellenthal et al. found that in 255 urology chief residents, the number of publications before residency significantly increased the number of manuscripts submitted during residency.[17]

Previous work has not yet consolidated the relationship between pre-residency publications and career trajectory. Herein, we assess the relationship between pre-residency publications, residency productivity, and after-residency career achievements in urologists. We hypothesized that total and first author pre-residency publication output were associated with increased publications during and after residency, fellowship pursuit, academic appointment, National Institutes of Health (NIH) grants obtained, and h-index.

## Materials and Methods

### Study Population and Variables

We obtained names of urologists graduating from residency between the years 2002 and 2008 from the top 50 urology hospitals in 2009, as ranked by U.S. News and World Report (www.health.usnews.com), by directly contacting programs.[18,19] Information collected included fellowship training (from residency program), appointment as of January 2020 (from urologist website), total NIH and R01 grants as of January 2020 (https://projectreporter.nih.gov/), and h-index in Scopus® database as of January 2020 (www.scopus.com). We received institutional review board exemption.

### Publication Data

We retrieved publications of the urologists before, during, and after residency. We queried PubMed using search terms of full name, last name with first and middle initial, last name with first initial, and last name with first initial with the word 'urology'. This search obtained lifetime publications of each urologist, which then underwent further investigation for crediting the publication. We credited publications to the urologist by meeting two criteria: 1) related to a urological topic and 2) affiliated with an institution the urologist spent time in. If only one of the two criteria were achieved, the manuscript was reviewed to ensure correct author affiliation. We collected data on each urologist's institutional affiliation from medical school to post-residency, so articles unrelated to urology could be correctly credited through the latter criterion. We discarded the manuscript if neither of the two criteria were met.

The research team (A.W.L., N.R., A.E.) reviewed the list of publications to determine type of each publication (original research, review, editorial/commentary, case report) and whether the participant was the first author. Pre-residency publications consisted of all manuscripts published any time during and prior to the year of residency matriculation. We totaled residency publications from two years before residency graduation to the year of residency graduation, ensuring the observed publications were actually

produced in residency. Post-residency publications included all articles published beyond the first calendar year after residency graduation; we excluded the first calendar year to discount publications likely completed during fellowship. Figure 1 demonstrates date ranges of data collection.

Statistical analysis

Descriptive statistics characterized demographic variables of the study population. Wilcoxon rank-sum **tests** compared all binary variables, while Cuzick nonparametric test of trend for ordered groups assessed trends across appointment. Odds ratios and 95% confidence intervals (CIs) were evaluated for relationship between at least one pre-residency publication (total and first author publications) and academic career achievement outcomes. Career achievements of residency publications, residency first author publications, h-index, post-residency publications, NIH grants, and NIH R01 grants were dichotomized based on the cohort's $90^{th}$ percentile in each respective category. Two-sided p-values less than .05 were considered statistically significant. We performed all statistical analysis using STATA V15 (Statacorp, College Station, TX).

**Results**

Subject Characteristics

A total of 36 of the top 50 urology hospitals possessed urology training programs and provided publicly available names of graduating residents. The study cohort contained 543 urologists, of whom 84 (15.5%) were women, 269 (49.5%) pursued fellowship, 183 (33.7%) entered academic career tracks, 45 (8.3%) received at least one NIH grant, 23 (4.2%) received at least one R01 grant, and 185 (34.1%) possessed an h-index of 10 or greater (max h-index: 79) (Table 1). A total of 161 (29.7%) and 92 (16.9%) participants published one or more total and first author manuscripts, respectively, before residency.

Pre-Residency Publications by Indicators of Career Academic Achievement

Urologists who pursued fellowship had significantly more first author publications before residency compared to those who did not (mean (SD): 0.4 (1.0) v. 0.2 (0.7), p=**0.0002**) (Table 2). Urologists who matriculated to an academic appointment had significantly more first author publications before residency compared to those who matriculated into private practice (mean (SD): 0.9 (1.6) v. 0.2 (0.6), p<**0.001**). Urologists who received NIH grants had significantly more first author publications before residency compared to those who did not (mean (SD): 0.6 (1.5) v. 0.3 (0.8), p=**0.02**). Urologists who received NIH R01 grants had significantly more first author publications before residency compared to those who did not (mean (SD): 0.9 (1.8) v. 0.3 (0.8), p=**0.0006**). Urologists who were in the top 10$^{th}$ percentile of total publication output after residency had significantly more first author publications before residency compared to those who were in the bottom 90$^{th}$ percentile of total publication output after residency (mean (SD): 0.8 (1.5) v. 0.2 (0.7), p=**0.0002**). Similarly, urologists with more publications in residency and a higher h-index had more first author and total publications before residency. Urologists with higher indicators of career academic achievement had more pre-residency original research and non-original research publications, compared to those with fewer career achievements (Supplemental Table 1).

Pre-Residency Publication Impact on Career Academic Achievement

A total of 92 participants published a first author publication before residency, 44 (47.8%) of whom entered academics, with 13 (14.1%) obtaining an NIH grant, including 10 (10.9%) with an R01 grant (Figure 2a). In comparison, 451 participants did not have a first author publication prior to residency; 144 (31.9%) of these participants went into academics, with 32 (7.1%) receiving an NIH grant, including 13 (2.9%) with an R01 (Figure 2b). Urologists who published at least one first author manuscript before residency had 1.9 increased odds (95% CI: 1.2-3.1, p=0.004) of entering academics, 2.2 increased odds (95% CI: 1.1-4.3, p=0.03) of receiving an NIH grant, and 4.1 increased odds (95% CI: 1.7-9.7, p=0.001) of obtaining an NIH R01 grant.

Moreover, 161 participants published at least one total manuscript before residency, of whom 61 (37.9%) entered academics, 14 (8.7%) acquired an NIH grant, and 10 (6.2%) received an R01 (Figure 2c). Comparatively, 382 participants did not publish prior to residency, of whom 127 (33.2%) entered academics, 31 (8.1%) acquired an NIH grant, and 13 (3.4%) obtained an R01 (Figure 2d). Urologists who published at least one manuscript before residency had 1.2 increased odds (95% CI: 0.8-1.8, p=0.31) of entering academics, 1.1 increased odds (95% CI: 0.6-2.1, p=0.22) of receiving an NIH grant, and 1.9 increased odds (95% CI: 0.8-4.4, p=0.14) of obtaining an NIH R01 grant.

**Discussion**

Our findings demonstrate that pursuing fellowship, obtaining an academic appointment, accruing NIH grants, and having significant post-residency publications were associated with increased pre-residency first author publications. Urologists who published more in residency and possessed a higher h-index had significantly increased total and first author pre-residency publications. Finally, urologists who had one or more first author publications before residency were more likely to enter academics and secure NIH grants.

Other studies have evaluated the relationship between publication productivity and academic career success for various specialties. Amongst neurosurgeons, Daniels et al. did not find a significant association between attaining academic faculty positions and pre-residency publication count.[14] Similarly, a single-institution analysis of neurosurgical trainees at University of California, San Francisco (n=54) corroborated a non-significant association between publications prior to residency and the decision to pursue academic practice.[20] The neurosurgery literature is inconsistent in its estimation of this relationship, however, as some studies identify strong associations between pre-residency publications and decisions to pursue an academic career in neurosurgery.[21] The contrast between our findings and those made by Daniels et al. and Lawton et al. may be secondary to the different time period under analysis (2002-2008 v. 2005-2015 v. 1968-2003), differing sample sizes, or other underlying attributes that may differentially characterize urologic and neurosurgical trainees. In otolaryngology, Kohlert et al. conducted an analysis on the impact of medical student research productivity on residency research productivity for trainees in Canada (n=312).[22] They identified a 5.85 increase in odds of having at least one publication prior to residency for residents with one or more residency publications compared to those with none published. This is consistent with our finding that residents within the top 10$^{th}$ percentile of publication productivity during residency had significantly more total and first author pre-residency publications. Radiation oncology trainees who had at least one pre-residency publication also had higher

h-indices and were two times more likely to choose an academic career than those who did not.[16,23] This too aligns with our findings that urologic residents who attain greater h-indices and academic appointments were more prolific in terms of publication prior to residency. Similarities in predictive factors for academic achievement in otolaryngology and radiation oncology may be due to structural parallels in residency format or underlying commonalities in trainee type.

In urology, Thompson et al. conducted an analysis on predictors of resident productivity and academic success including medical school publication count, residency publication count, and quality of publication (n=49).[15] Publications before residency were predictors for publishing at least six residency publications (OR: 2.83, p=0.091), publishing at least three quality residency publications (OR: 3.20, p=0.067), fellowship pursuit (OR: 3.25, p=0.057), and pursuit of an academic career (OR: 3.65, p=0.04). This study, compared to ours, utilized a smaller sample size and single institution selection. Our study did not define residency productivity by publication number, but rather by percentile within the study cohort. Nevertheless, our findings remain consistent, as we also found total publications before residency increased odds of publications during residency, fellowship pursuit, and academic faculty positions. Hellenthal et al. reported consistent results with our study in which the number of pre-residency publications were significantly predictive of the number of manuscripts submitted during residency.[17] In sum, our study adds to the current literature a well-powered, 20-year longitudinal analysis assessing predictive factors in urologic academic achievement.

Our results indicate a positive association between pre-resident research productivity and metrics of career academic achievement including academic appointment and NIH grant securement. This suggests that increased contributions to the literature before residency can portend academic success in the future. An important distinction to be made is that our study only identified first author pre-residency publications as a significant driver of academic appointment and securement of NIH grants, though not total publication count in the pre-residency period. This discrepancy may be attributable to first author

research productivity before residency connoting inherent investigational merit more so than general publications in which said individual's contribution may not necessarily be indicative of academic interest. It may also be related to increased intellectual ownership required in first author publication in terms of design and execution of the study which may better correlate with similar capacities evaluated in NIH grant review. However, publications and grants do not necessarily reflect clinical and surgical ability. Further studies will help inform a more granular understanding of precise relationships between publication type and different forms of career achievement.

Study limitations include the limited number of urologists analyzed who were residents between 2002-2008, which may not necessarily represent the current landscape in terms of predicting academic potential. We used the U.S. News and World Report top 50 as a proxy for higher tier academic urology programs, although many excellent programs are not included annually. Including all programs would have been more comprehensive, though may have decreased our study's percentage of academic urologists - the group we were most curious about. We hope to expand our study cohort in the future to compare the findings with programs not included in the top 50 ranking. We did not collect information on higher degrees (i.e. PhDs) or consider medical school in our analysis, which are likely significant contributors to publication output. Further, our data regarding pre-residency publications is not normally distributed and is right-skewed. Though not a structural limitation, it does inform to what extent statistical differences are meaningful when comparing across strata. The names of residents graduating between 2005 and 2008 from six programs were not made available to us at the time of the study. This led to a drop in subjects from 2004 to 2005. Additionally, our study's absolute differences in pre-residency publications were modest and despite statistical significance may not necessarily be meaningful. Finally, some publications written by authors on topics outside of urology and not affiliated with their home institution may have been excluded. The numbers of publications are further under-estimated because we only included searchable publications on PubMed.

**Conclusions**

Taken together, our study underscores the pertinence of pre-residency publication output in predicting eventual career and academic achievements. These findings hold implications for graduate medical education, as publications before residency can impact a trainee's propensity towards future academic achievement. This can inform both selection procedures of residency programs and residency curricular development to facilitate academic growth and career success. Future research can survey whether the predictive impact of publication output differs with more recent generation of trainees and with publication-level heterogeneity.

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**Tables**

**Table 1.** Characteristics of urologists graduating residency between 2002 to 2008 from top 50 urology hospitals.

| | n (%) |
|---|---|
| **Final Year of Residency** | |
| 2002 | 83 (15.3) |
| 2003 | 85 (15.7) |
| 2004 | 85 (15.7) |
| 2005 | 70 (12.9) |
| 2006 | 72 (13.3) |
| 2007 | 76 (14.0) |
| 2008 | 72 (13.3) |
| **Gender** | |
| Men | 459 (84.5) |
| Women | 84 (15.5) |
| **Fellowship** | |
| No | 274 (50.5) |
| Yes | 269 (49.5) |
| **Current post-residency position** | |
| Private Practice | 360 (66.3) |
| Assistant | 48 (8.8) |
| Associate | 77 (14.2) |
| Professor | 43 (7.9) |
| Chair | 15 (2.8) |
| **NIH Grants** | |
| Total Grants | |
| 0 | 498 (91.7) |
| >1 | 45 (8.3) |
| R01 Grants | |
| 0 | 520 (95.8) |
| ≥1 | 23 (4.2) |
| **h-index** | |
| 0-2 | 175 (32.2) |
| 3-9 | 183 (33.7) |
| ≥10 | 185 (34.1) |
| **Total Publications** | |
| Pre-Residency | |
| 0 | 382 (70.3) |
| 1 | 83 (15.3) |

| | |
|---|---|
| ≥2 | 78 (14.4) |
| During Residency | |
| 0 | 87 (16.0) |
| 1-3 | 243 (44.8) |
| ≥4 | 213 (39.2) |
| Post-Residency | |
| 0 | 206 (37.9) |
| 1-5 | 135 (24.9) |
| 6-29 | 93 (17.1) |
| ≥30 | 109 (20.1) |
| **First Author Publications** | |
| Pre-Residency | |
| 0 | 451 (83.1) |
| ≥1 | 92 (16.9) |
| During Residency | |
| 0 | 168 (30.9) |
| 1-2 | 204 (37.6) |
| ≥3 | 171 (31.5) |
| **Pre-Residency Publication Article Type** | |
| Original Research | |
| 0 | 407 (75.0) |
| ≥1 | 136 (25.0) |
| Reviews | |
| 0 | 515 (94.8) |
| ≥1 | 28 (5.2) |
| Editorials/Commentaries | |
| 0 | 539 (99.3) |
| ≥1 | 4 (0.7) |
| Case Reports | |
| 0 | 511 (94.1) |
| ≥1 | 32 (5.9) |

**Table 2.** Urologist total and first author pre-residency publications stratified by urologist characteristics. Career achievements were divided into top performers (above 90th percentile) with the following cut-offs: Residency Publications 90th percentile=10, Residency First Author Publications 90th percentile=5, h-index 90th percentile=26, Post-Residency Publications 90th percentile=87. Less than 10% of urologists had an NIH grant or R01 grant; top performers in these two categories were those with at least 1 grant.

| | **Mean/Median Publication (min-max)** | | | |
|---|---|---|---|---|
| | Total | P value | First author | P value |
| **Overall** | 0.8/0 (0-24) | | 0.3/0 (0-8) | |
| **Residency Publications** | | | | |
| <90th percentile | 0.7/0 (0-24) | | 0.2/0 (0-6) | |
| >90th percentile | 1.6/0 (0-13) | 0.**001** | 0.8/0 (0-8) | <0.**0001** |
| **Residency First Author Publications** | | | | |
| <90th percentile | 0.7/0 (0-24) | | 0.2/0 (1-6) | |
| >90th percentile | 1.5/0 (1-13) | 0.**0008** | 0.7/0 (1-8) | <0.**0001** |
| **Fellowship** | | | | |
| No | 0.6/0 (0-10) | | 0.2/0 (0-6) | |
| Yes | 0.9/0 (0-24) | 0.**15** | 0.4/0 (0-8) | 0.**0002** |
| **Appointment** | | | | |
| Private Practice | 0.7/0 (0-24) | | 0.2/0 (0-6) | |
| Assistant | 0.5/0 (0-3) | | 0.3/0 (0-2) | |
| Associate | 0.9/0 (0-22) | | 0.4/0 (0-5) | |
| Professor | 1.2/0 (0-13) | | 0.8/0 (0-8) | |
| Chair | 1.4/0 (0-8) | 0.12 | 0.9/0 (0-5) | <0.001 |
| **Total NIH Grants** | | | | |
| 0 | 0.7/0 (0-24) | | 0.3/0 (0-6) | |
| ≥1 | 1.0/0 (0-11) | 0.**61** | 0.6/0 (0-8) | 0.**02** |
| **R01 Grants** | | | | |

| | | | | |
|---|---|---|---|---|
| 0 | 0.7/0 (0-24) | | 0.3/0 (0-6) | |
| ≥1 | 1.3/0 (0-11) | 0.**11** | 0.9/0 (0-8) | 0.**0006** |
| **h-index** | | | | |
| <90$^{th}$ percentile | 0.6/0 (0-24) | | 0.2/0 (0-6) | |
| >90$^{th}$ percentile | 1.9/0 (0-22) | 0.**002** | 1.0/0 (0-8) | <0.**0001** |
| **Post-Residency Publications** | | | | |
| <90$^{th}$ percentile | 0.7/0 (0-24) | | 0.2/0 (0-6) | |
| >90$^{th}$ percentile | 1.3/0 (0-13) | 0.**05** | 0.8/0 (0-8) | 0.**0002** |

**Figures**

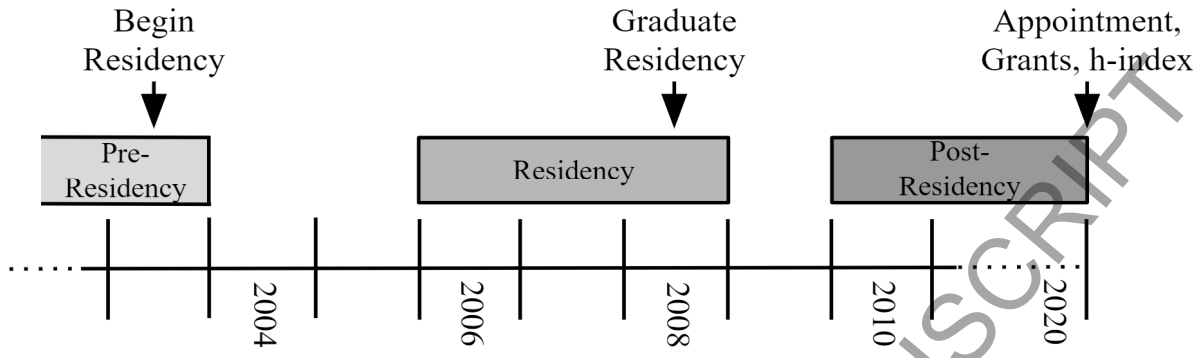


**Figure 1**. Timeline of data collection for a urologist graduating residency in 2008. Publications during and before the first year of residency comprised pre-residency publications; residency publications included manuscripts published during and two years prior to year of residency graduation. Post-residency publications included those beyond the first calendar year after residency graduation. Appointment, grants, and h-index for each urologist were collected in 2020.

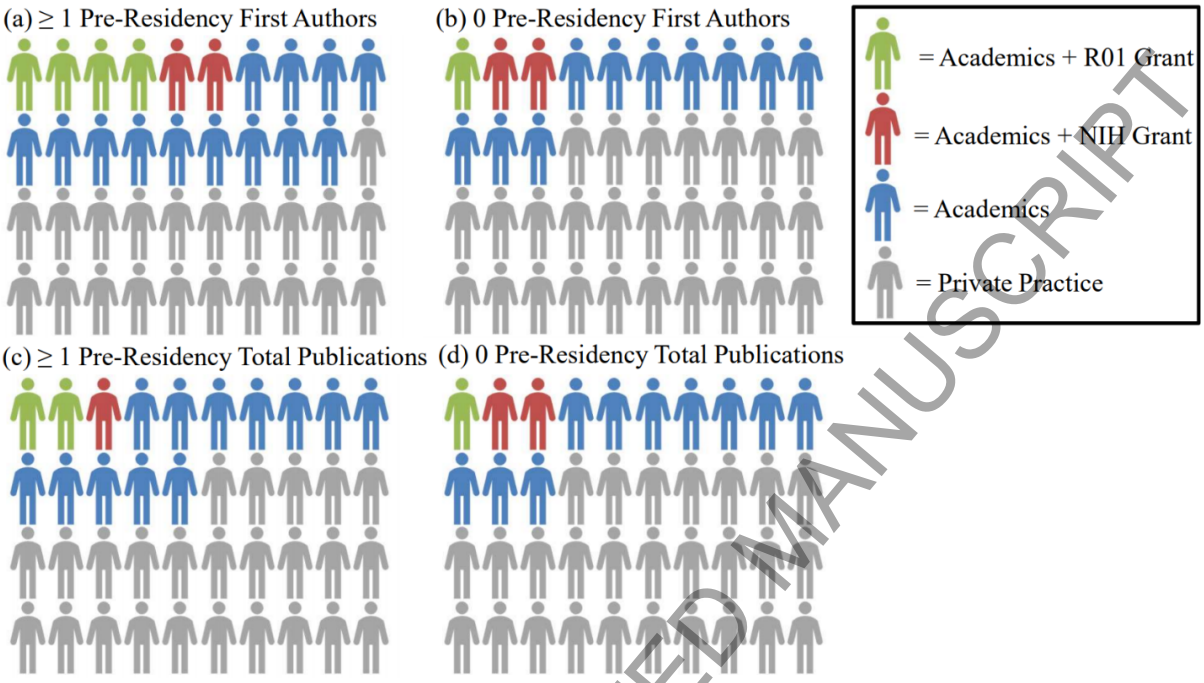


**Figure 2.** Pre-residency publication implications on career academic achievement. Proportion of urologists who entered academics (blue), obtained an NIH grant (red), and NIH R01 grant (green) after publishing at least one first author publication (**Figure 2a**), no first author publications (**Figure 2b**), at least one total publication (**Figure 2c**), and no total publications (**Figure 2d**) before entering residency.