

Effect of Medical Student Contributions on Academic Productivity: Analysis of Student Authorship Over Time

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Introduction: Understanding the trend of student authorship is crucial in determining its correlation to scholarly impact for corresponding authors. Our objective is to investigate student authorship rates over time in articles published in JAMA Internal Medicine (IM), as well as to examine potential effects student authors have on scholarly impact scores of corresponding authors via H-index measures.

Methods: Authorship data including student authors (SA), first student authors, and corresponding authors (CA) from prior JAMA IM publications between 2010 and 2018 were collected, with a total of 701 studies. Analysis of variance (ANOVA) and independent sample *t*-tests were performed to assess for differences in the mean by publishing year and student authorship, respectively.

Results: Of 4591 total authors, 683 (14.9%) were considered student authors. The percentage of student authorship increased from 46.3% to 58.0% between 2010 and 2018, respectively. No difference in average H-indices of CA between SA and non-SA groups (overall NSA H_i mean: 30.2, vs SA H_i mean: 32.1, *p*=0.371) was noted.

Discussion: Student participation in research is not a disadvantage to scholarly impact for corresponding authors. Increased student authorship reflects a promising trend towards greater student participation in research within the field of medicine.

Keywords: student research, medical student, academic productivity, H-index, authorship

Introduction

Research remains an integral component for academic medical professionals, as scholarly productivity is frequently used as a consideration for faculty promotion.¹⁻³ Its importance and impact on clinical care management have also trickled down into medical education. Given that research participation has been shown to develop critical skills for post-graduate success, many medical schools now offer research electives to promote scholarly pursuits.⁴⁻⁹ As the overall demand for residency programs continues to increase, extracurricular activities, including research, have become encouraged in bolstering applicants' overall competitiveness for the National Resident Matching Program (NRMP).^{10,11} In 2018, approximately 78.0% of students reported during research during medical school according to NRMP Charting Outcomes, of which students published an average of 5.8 publications across all specialty applications.¹² This is compared to 2009, where these same reports showed an average of 2.2 publications.¹³

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From a medical student perspective, students also gain valuable experiences from research involvement. Previous work had noted stronger student-faculty relationships, more reformed academic skills as critical thinking and review, increased productivity, and long-term mentorship for students pursuing research compared to their counterparts.^{14–18}

Despite these benefits, students have noted multiple obstacles in undertaking research projects. For example, time constraints during medical school can pose challenges in designing and implementing research proposals from start to finish.^{19–21} Others reported coordination difficulties from mentors due to increasing demands on clinician educators for concurrent roles.^{15,21,22} Inherent difficulties in research completion – including IRB approval, patient consent process, as well as data collection and analyses – can also contribute to the challenges of performing research in general.²⁰

Since its development in 2005, the H-index (H_i) has been widely utilized as a biometric indicator in evaluating research productivity.^{23,24} As a parameter to quantify individuals' scientific output and scholarly impact in a given year, it can be applied to any set of papers, journals, counties, and even within specific fields.^{25–30} For our purposes, the H-index can also be used to assess the impact of student authorship on published research as a quantitative measure of author productivity.

To date, studies examining student authorship and mentorship in medical research are limited. There have been previous studies examining specific career fields, for instance, surgical specialties and radiation oncology, though no papers have looked at broader career fields as indicators of more generalized student trends.^{31,32} Given the size and breadth of internal medicine as a field, this will offer insight into the underlying changes of student authorship on scholarly impact for a large cohort population.

Here our objectives are two-fold: first, to analyze student authorship rates over time in the Journal of the American Medical Association (JAMA) Internal Medicine, and second, to examine the effects student authors have on the scholarly impact of corresponding authors (CA) in a major medical journal over time utilizing H-index scores.

Methods

All authors from articles published in the Journal of the American Medical Association Internal Medicine (JAMA

IM) during the years of 2010, 2014, and 2018 were identified and ascribed into a compiled database. Each author's degree was recorded, with designations assigned as either corresponding author (CA), student author (SA), or other author. Other data points were documented: number of total authors, SA placement(s), SA degree(s), type of published article, CA's geographic location, as well as CA's H-score. The student author was defined as an author with a non-doctoral, non-medical degree; for example, NPs, RNs, authors with bachelor degrees, master's degrees, and Ph.D. candidates were considered student authors. Student authors who were also first authors (FA) were especially noted during data collection to assist in subsequent subset analyses. Inclusion criteria for journal articles included: original investigations, systematic reviews, evidence to practice, research letters, teaching moments, case report/case series, clinical observation, and special communication articles.

For each of the sampled years, H_i scores were identified for CA at the time of publication of the article, as determined by Scopus.³³ For CA, who had publications in multiple years, all H_i were tabulated over time. Published articles were divided into two groups: articles with SA and those without student authors (nSA). CA, with multiple publications within the same year, were only counted once and designated as having student authors if at least one of their publications had a SA. All data were collected from September 2019 to February 2020.

Descriptive statistics were computed to describe the study cohort. Results are expressed as mean (standard deviation), median (interquartile range), and number (column percent). Geographic classifications within the United States (US) followed standard region stratifications (Northeast, Midwest, South, West). Analysis of variance (ANOVA) and independent sample *t*-tests were performed to assess for differences in the mean by publishing year and student authorship, respectively. Chi-square analyses (Fisher exact test for small samples) were used to evaluate differences in categorical variables. Linear data trends were examined by assessing the goodness of fit model based on the means of H_i scores presented and reported as the value of R^2 (range 0–1). A *p*-value of <0.05 was considered statistically significant for all analyses. All statistical computations were performed on SAS 9.3 software (SAS Institute, Cary, NC).

Results

A total of 701 articles were published in JAMA Internal Medicine, stratified as 246, 248, and 207 articles in the

Table 1 Descriptive Analyses of Publications from 2010 to 2018 in JAMA Internal Medicine

	All		2010		2014		2018	
Total number of articles	701		246		248		207	
Number of all authors	4591		1643		1578		1370	
Number of student authors	683		205		214		264	
% of student authors	14.9		12.5		13.6		19.3	
# Papers with Student Authors	n	%*	n	%	n	%	n	%
No	341	48.6	132	53.7	122	49.2	87	42.0
Yes	360	51.4	114	46.3	126	50.8	120	58.0
1	175	48.6	53	46.5	71	56.4	51	42.5
2	111	30.8	43	37.7	32	25.4	36	30.0
3 or more	74	20.6	18	15.8	23	18.3	33	27.5
# of first authors as students	73	20.3	20	17.5	23	18.3	30	25.0
# of Authors per Paper	n	%	n	%	n	%	n	%
1 to 5	335	47.8	114	46.3	130	52.4	91	44.0
6 to 10	285	40.7	105	42.7	88	35.5	92	44.4
11 to 15	54	7.7	18	7.3	22	8.9	14	6.8
16 or more	27	3.9	9	3.7	8	3.2	10	4.8

Note: *Proportion (%) over denominator of total articles in that year.

Abbreviation: n, number.

years 2010, 2014, and 2018, respectively (Table 1). Of 4591 total authors, 683 (14.9%) were classified as student authors. The percentage of student authorship was seen to increase over time, where the percentage of authors identified as students rose from 12.5% in 2010 to 13.6% in 2014 and 19.3% in 2018.

Approximately 46.3% of articles included at least one student author in 2010, compared to 58.0% in 2018. Figure 1 shows the overall number of publications with at least one student author over time ($R^2 = 0.9825$). Of the papers with student author(s), the majority of these papers (mean 79.4%) had between one and two student authors, with the rest of the papers including more than two student authors (Table 1). The percentage of students as first authors also increased over time, rising from 17.5% in 2010 to 25.0% by 2018.

H_i for CA with and without SA involvement was found to be similar across both groups (nSA: 30.2, vs SA: 32.1, $P=0.371$, Table 2). Year-specific H_i scores seemed slightly higher for SA as compared to nSA, though the results were not statistically significant ($P>0.05$). (Figure 2). In looking at the number of publications stratified by the geographic location of CA, the majority of articles (540/701)

originated from the US, followed by Europe (n=95) and Canada (n=32, Table 3). Of the publications arising from the United States, approximately half of the papers came from the Northeast, with smaller proportions from the South and West. Interestingly, regardless of geographic region stratification, at least half of the US publications (range 50.3–58.1%, $P=0.149$) included at least one student author in their author line.

Europe had the second-highest number of articles published overall, though the rates for student authorship were not as high as those from the US. In other words, approximately 37.9% of papers published in Europe had at least one student author, compared to a mean of 53.3% articles published in the US with at least one student author. The rest of the student-authored publications came from CAs located in Canada, China/Hong Kong, and Taiwan, among others.

Discussion

In most academic medical centers, research stands as an important factor for long-term academic success.^{34,35} Studies have shown that the effort spent on research plays a crucial role in the academic promotions of faculty.^{36–39} For medical education, involving students in

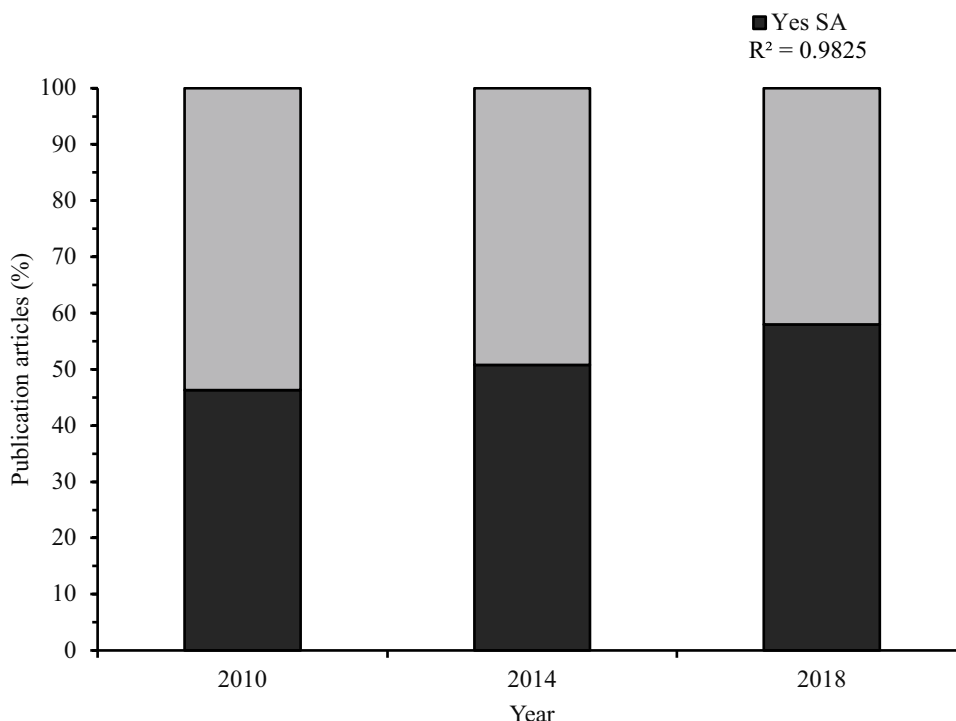


Figure 1 Distribution of publications (n=701) comparing articles with ≥1 student authors (SA) versus those with no student authors (no SA) between 2010 to 2018 in JAMA Internal Medicine.

research helps develop professional skills key to continued academic success.⁴⁰ In addition, research has become a constant consideration in NRMP residency applications, with both the number of research projects and the number of published works playing increasingly larger roles.^{41,42}

While the role of research has traditionally been strong for applicants matching into number-limiting fields such as surgical sub-specialties, radiology, radiation oncology, and dermatology, applicants for internal medicine have shown a steady increase in research work as well.^{12,13,43–45} Despite the fact that internal medicine continues to be

the largest residency by number, data on student authorship rates in medicine and its effect on scholarly impact remain limited.⁴⁶

Our data show an overall increase in student authorship in JAMA Internal Medicine from 2010 to 2018, where the percentage of publications with at least one student author increased from 46.3% to 58.0%, respectively. The percentage of publications with first student authors had also increased as well, highlighting the trend towards greater student participation in research and suggesting increasing interest in the field of medicine. Our study demonstrates

Table 2 Mean H-Index (n=701) of Corresponding Authors' (CA) Publications with (SA) or without (nSA) Student Authors Over Time in JAMA Internal Medicine

Year	No Student Authors				Student Authors				P
	n	Mean (SD)	Median	95% CI	n	Mean (SD)	Median	95% CI	
All	341	30.2 (30.2)	24.0	27.0–33.4	360	32.1 (26.0)	26.5	29.4–34.8	0.371
2010	132	35.0 (29.8)	26.5	29.9–40.2	114	38.1 (25.0)	34.0	33.5–42.8	0.383
2014	122	32.3 (31.7)	26.5	26.7–38.0	126	34.2 (30.6)	25.5	28.8–39.6	0.641
2018	87	19.8 (26.3)	10.0	14.2–25.4	120	24.2 (19.0)	19.0	20.7–27.6	0.189

Abbreviations: n, number; SD, standard deviation; CI, confidence interval.

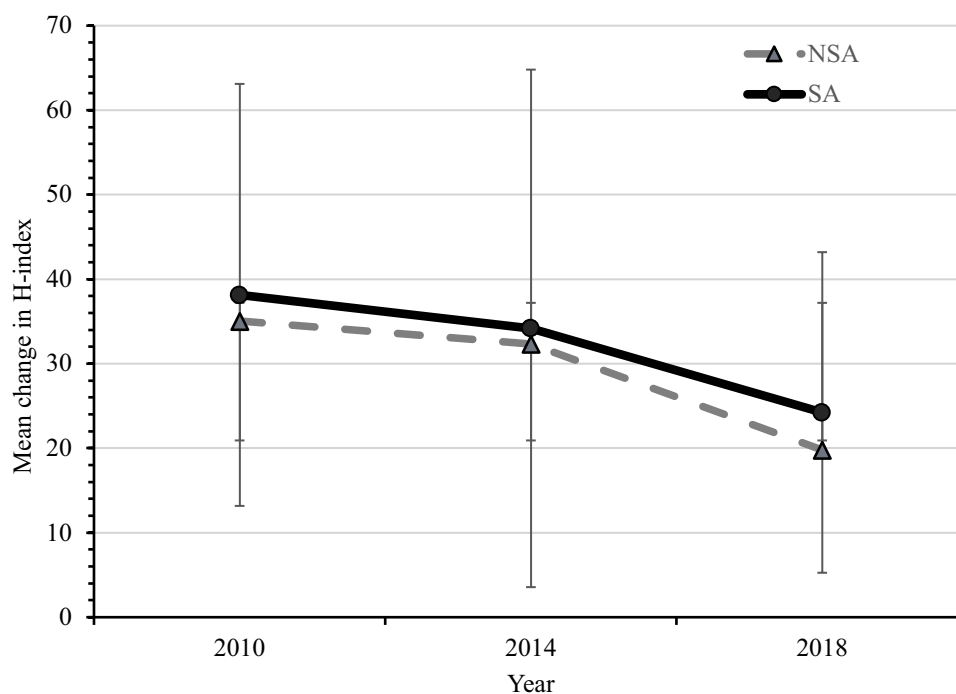


Figure 2 Change in mean H-index and respective standard deviations (n=701) for corresponding authors (CA) in articles published in JAMA Internal Medicine 2010–2018 between publications with student authors (SA) and without SA (nSA).

no difference in the average H-indices of CA between SA and nSA groups.

Generally speaking, authorship trends have slowly increased over time, showing that the number of authors, in general, have increased over the last few decades. In An et al, through a cumulative four urologic journals, authorship counts in original research articles increased by an average of 2.45 per manuscript (43.3% increase) in the last ten years.⁴⁷ Another paper by Filardo et al looked at trends of female first authorship from 1994–2014, to which women representation was significantly higher in the last twenty years.⁴⁸ The gradual increase in overall authorship counts over time may be attributed to increased cooperation and interdisciplinary collaboration. Per An, they noted the need for increased specialization and drawing of experts for more impactful studies, as well as increasing scientific requirements for peer-reviewed publications, as possible reasons for the increasing trend of authorship counts.⁴⁷ As for student authorship, per Munzer et al, sixteen journals were taken in composite review for overall student authorship trends, where student authors represent a small but growing proportion of authors in publications overall, not specific to one journal or our current study.⁴⁹

Furthermore, the relationship between student and mentor has always been closely aligned, with similar end goals but varying reasons for collaboration. For students, motivational factors involve good mentorship, especially in pursuing potential career options, better proficiency in the research process, further understanding of biostatistics applications, and the overall opportunity to publish original work.⁵⁰ For mentors, the literature on mentoring reasons is not as clearly stated. While some studies note overall interest in teaching others about research, other studies noted more personal gain of productivity by involving more people in their research.⁵¹ In our study, given that it is retrospective and compiling on previously published works, further insight into contributing factors of how student authors became involved in the first place would be limited.

With our study, however, we do show that the employment of student authors does not negatively impact the academic production and thereby the promotional aspirations of faculty.

Regarding measurable outcomes, these can again be derived quantitatively via the H-index, which indirectly notes an author's overall productivity, taking into account the quality of the journal, the measured impact of said research, and the number of research publications. While

Table 3 Number of Papers with Student Authors: Overall and by Year

Authorship by Region/Country	Type of Author	All Years		2010		2014		2018		P for Trend
		n (Percent)								
Total	All Student*	701 360	51.4	246 114	46.3	248 126	50.8	207 120	58	0.014
United States	All Student	540 288	53.3	161 81	50.3	207 107	51.7	172 100	58.1	0.149
District of Columbia	All Student	7 7	100	2 2	100	2 2	100	3 3	100	N/A
Northeast	All Student	208 108	51.9	60 29	48.3	86 47	54.7	62 32	51.6	0.722
Midwest	All Student	76 42	55.3	23 16	69.6	29 14	48.3	24 12	50	0.182
South	All Student	131 69	52.7	40 18	45	49 26	53.1	42 25	59.5	0.188
West	All Student	118 62	52.5	36 16	44.4	41 18	43.9	41 28	68.3	0.032
Canada	All Student	32 21	65.6	12 8	66.7	7 5	71.4	13 8	61.5	0.782
Europe	All Student	95 36	37.9	56 20	35.7	25 10	40	14 6	42.9	0.582
Netherlands	All Student	18 7	38.9	13 6	46.2	4 1	25	1 0	0	0.264
France	All Student	12 7	58.3	7 3	42.9	3 2	66.7	2 2	100	0.139
UK	All Student	12 4	33.3	5 1	20	3 1	33.3	4 2	50	0.344
Germany	All Student	9 3	33.3	6 1	16.7	3 2	33.3	0 0		N/A
Denmark	All Student	7 5	71.4	1 1	100	4 3	75	2 1	50	0.35
Sweden	All Student	6 4	66.7	4 3	75	1 1	100	1 0	0	0.257
Other**	All Student	31 6	19.4	20 5	25.0	7 0	0	4 1	25.0	0.565
Asia	All Student	23 11	47.8	10 2	20	7 4	57.1	6 5	83.3	0.012
China/HK	All Student	8 5	62.5	3 0	0	3 3	100	2 2	100	0.014
Taiwan	All Student	6 2	33.3	3 0	0	2 1	50	1 1	100	0.053

(Continued)

Table 3 (Continued).

Authorship by Region/Country	Type of Author	All Years		2010		2014		2018		P for Trend
Other***	All	9		4		2		3		0.733
	Student	4	44.4	2	50	0	0	2	66.7	
Australia/NZ	All	11		7		2		2		0.884
	Student	4	36.4	3	42.9	0	0	1	50	

Notes: *Student denotes that at least one student author was included in the publication's author line. **Other Europe: Belgium 2, Finland 4, Ireland 1, Israel 3, Italy 8, Norway 1, Portugal 1, Spain 3, Switzerland 6, Turkey 2, = 31 total. ***Other Asia: India 3, Japan 2, Korea 1, Singapore 3, = 9 total.

in our study, the H-index between papers with student authors and without student authors was not statistically significant ($p=0.371$); however this does not exclude the potential qualitative outcomes of having student authors involved in research studies. Through an integrated mixed-methods systematic review and meta-analyses, Amgad et al found that medical students who participated in the research were associated with improved short and long-term scientific productivity, more informed career choices, and improved knowledge and interest in research.⁵² Similar findings were noted in Cheung et al, as well as Laidlaw, both of which also commented on developing lifelong research skills beneficial in honing on evidence-based medicine in future years.^{53,54} Whereas student-reported barriers to research often highlight a perceived lack of interest from potential mentors, our data suggests a potentially mutually beneficial relationship. Previous studies looking at the correlation between medical student involvement and faculty scholarly productivity have similarly shown either a beneficial or neutral relationship, corresponding to our current findings.^{55,56} Whereas faculty can offer mentorship and research expertise, students have the added benefit of time to contribute and, in return, become involved in research projects to stimulate their careers.^{57,58} Indeed, it is likely that the addition of student authors adds proof of academic mentorship, which is also often employed as a measure for faculty promotion.⁵⁸⁻⁶⁰

There are several limitations to our study. This study is retrospective and, as such, may suffer from selection bias. Specifically, given that the papers included in our research were preselected for publications, there would be selection bias as to which studies were considered in our study. While H_i scores are not a reliable surrogate for scholarly impact, they remain widely used to identify research. The actual number of student authors may vary from our numbers. For instance, we identified all

non-doctorate authors as student authors, which may overestimate the number. On the opposite end, the time interval between research and publication may lead to graduate degrees for those who performed their research while students, underestimating the number. However, since our comparisons are consistent over time, we believe our interpretation of the data is appropriate. Students may seek research mentors with higher H_i scores, artificially elevating scores of CAs with SA. Finally, this information is collected from a single leading journal of internal medicine; however, as the journal represents a broad range of medicine disciplines with a high impact factor of 20.8, we feel that JAMA Internal Medicine is an appropriate journal to best evaluate student authorship in internal medicine. Further studies on understanding the underlying decision-making in choosing research mentors may help identify patterns of student authorship.

Conclusion

The rate of student authorship in JAMA Internal Medicine increased between 2010 and 2018. Student participation in research does not negatively impact author productivity, and may in fact benefit faculty promotion when mentorship is evaluated. This mutually beneficial relationship between the corresponding author and students should encourage more faculty to seek out student mentees.

Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Disclosure

The authors have stated that they have no conflicts of interest.

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