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Trends in Medical Student-Authored Publications, 2012-2022

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ABSTRACT

Purpose

To analyze trends in the quantity and quality of medical student-authored publications from 2012 to 2022.

Methods

We searched PubMed to identify all articles with an author affiliation listed as “medical student” from 2012 to 2022. We manually reviewed articles to determine study design and cross-referenced articles with Semantic Scholar and Scimagojr databases to determine citation count and journal rank data. As a secondary exploratory analysis, we then reviewed the websites for the 100 journals with the most medical student publications during the study period to determine whether they had mandatory fees associated with publishing.

Results

We identified 5,591 articles with medical student authors, of which 5,181 met the inclusion criteria. The number of articles increased by 1,329% from 2012 to 2022. The median Scimago Scientific Journal Ranking of medical student publications increased from 2012 to 2022 (0.470 to 0.630, p=0.0002). The proportion of articles published in a top quartile journal was 29% in 2012 and 41% in 2022 (p=0.09). Twenty-three percent of medical student-authored articles received zero citations. There was a relative increase in medical student-authored perspective articles (from 6% in 2012 to 23% in 2022; p=0.002) and a decrease in case reports (from 26% in 2012 to 14% in 2022; p=0.02). The proportion of papers published in journals with publication fees increased from 3.7% in 2012 to 14.8% in 2022 (p=0.02).

Conclusions

Between 2012 and 2022, the quantity of medical student research on PubMed increased more than tenfold. There was a relative increase in perspective papers and a decrease in case reports. Approximately one in four medical student papers were never cited, and approximately one in six were published in a journal with a publication fee.

INTRODUCTION

For nearly 100 years, the phrase “publish or perish” has been used to describe the pressure to publish scholarly work to succeed in academia [1]. Such pressure is well known among medical school faculty, who perceive their total number

of publications to be the most important factor for promotion and tenure [2]. Yet medical students also perceive pressure to publish, often reporting that the primary reason they perform research is to advance professionally [3]. This aligns with self-determination theory, which distinguishes between intrinsic motivation (driven by interest or personal value) and extrinsic motivation (driven by external rewards or pressures) [4]. In this context, medical student research is driven, at least in part, by extrinsic motivation, particularly the pressure to bolster residency applications.

This pressure translates to an increasing quantity of research publications to achieve these external incentives, especially in highly competitive postgraduate education systems like the United States [5,6]. This pattern reflects Goodhart's Law, which cautions that "when a measure becomes a target, it ceases to be a good measure" [7,8]. Subsequently, as publication count becomes a proxy for residency applicant quality, it may lose its evaluative value by inadvertently incentivizing strategic publishing aimed at boosting metrics rather than performing high-quality work.

Previously, Wickramasinghe et al. described an exponential increase in medical student research on PubMed from 1980 to 2012 [9]. They found that the majority of student research was never cited a single time. Since then, however, no data have been published evaluating the quantity and quality of medical student research on PubMed.

We therefore evaluated the quantity of medical student research on PubMed from 2012-2022 and the quality indicators of these articles, including their journal rankings, citation metrics, and study design. In addition, we set a secondary exploratory objective to estimate some of the associated costs of these publications to generate future hypotheses. We hypothesized that from 2012 to 2022, the quantity of medical student research would increase, its quality would decrease, and its cost would increase.

METHODS

Article identification and data collection

We searched PubMed® in August 2023 for the keywords "medical student" in the author affiliation field. We then uploaded the citations for all returned articles published from January 1, 2012, to December 31, 2022, to an open-source reference management software platform (Zotero; Fairfax, VA). We reviewed all items to exclude duplicate publications (identified by exact title match); retracted publications (using Zotero's retraction checker); video publications (using their PubMed classification); and articles that were published outside the study period (by manual review of publication date). We reviewed author affiliations, excluding articles where the author tagged by the "medical student" query was clearly not a student.

We used the available Zotero plugin to extract Semantic Scholar citation counts. To ensure accuracy, we randomly sampled 20 publications to confirm an identical match between the number of citations returned by the plugin and that reported by Semantic Scholar (Allen Institute for AI; Seattle, WA).

We downloaded the PubMed text for all articles, including the listed author affiliations. These data were cross-referenced with the data sheet obtained from Zotero to list author affiliations next to the data results. Affiliations were screened for an author who could be identified as a medical student. Articles without any medical

student author affiliation were removed.

To approximate journal quality, we used the Scimago Journal Rank (SJR) [10]. The SJR calculates an eigenvector centrality measure for journals that incorporates both the average number of citations received by a journal and the prestige of the journals in which the articles are cited. We downloaded Scimago's journal data and cross-referenced it with the PubMed data based on the journal titles. While we used the 2022 SJR rankings as a surrogate for journal quality in our analyses, we also downloaded the 2012 SJRs and compared them to the 2022 SJRs to determine if temporal variability would impact the results.

Research design assessment

Three authors (BE, ZG, and ES) manually evaluated publications and categorized each publication as a case report/case series, review article (either systematic or general), perspective (including editorials, reply publications, letters to the editor, and other opinion publications), cross-sectional, case-control, retrospective cohort, prospective observational, interventional trials, basic science research, medical education interventions, and other. Using a standard set of instructions, each reviewing author evaluated 10 random articles and independently determined the design during a trial period. These results were used to calculate a fixed-marginal kappa for inter-rater reliability. Each of these authors then received approximately 1/3 of the database and used the standard instructions (Supplement 1) for determining research design, in accordance with best practices for data abstraction [11].

Publication cost assessment

To estimate the cost of article publication, we evaluated the article processing fees required by the 100 journals that published the largest number of medical student-authored publications during the study period. For each of these journals, we reviewed submission guidelines listed on the journal website and noted the mandatory submission, publication, and/or publication cost (if any) for an original research article submitted from the United States as of March 2024. All currencies were equated to United States Dollars using Google exchange rates as of March 2024. For journals that offered a free standard submission or paid open-access option, we assumed all authors opted for standard submission.

Data analysis and statistics

Descriptive statistics were done with Microsoft Excel version 2312. Statistical comparisons were done with GraphPad Prism version 10.1.2 for Windows. Continuous variables were compared using the Mann-Whitney test. Categorical variables were compared using Fisher's exact test. Outcomes were analyzed for statistical change between the first year (2012) and the last year (2022) of the study period.

RESULTS

We identified 5,591 PubMed-indexed articles from 2012 to 2022 that listed a medical student author (Supplemental Figure 1). We then excluded 15 articles that were published before 2012 and 149 published after 2022. We also excluded three retracted papers, four duplicate articles, 10 videos, and eight corrections to previously published articles. The remaining 5,402 articles were screened for medical student affiliations, and 221 articles were removed for having no clearly identified medical student author. Typically, these articles had a faculty affiliation such as "Office of Medical Student…" that was captured by the PubMed search. This

resulted in the study sample of 5,181 medical student-authored publications, which we then analyzed further.

From 2012 to 2022, the number of medical student-authored PubMed-indexed publications increased by 1,329% (Figure 1). 50% of articles had a medical student as the first author, and 36% had a medical student as the second author. In 29% of articles, no medical student was the first or second author, and 14% of articles had medical students as both the first and second authors. The percentage of articles with a medical student first author decreased from 63% in 2012 to 48% in 2022 (p=0.048), and the percentage with a medical student second author increased from 17% in 2012 to 39% in 2022 (p=0.001). The percentage of articles without a medical student first or second author was similar between 2012 – 24% and 2022 – 31% (p=0.36).

Overall, 4,532 (87%) articles were published in journals that had 2022 rankings in SJR. A total of 1,134 individual journals published the articles, of which 870 of 1134 (77%) had 2012 and 2022 rankings. The highest 2022 ranking was 86.09 (CA: A Cancer Journal for Clinicians), the median was 0.603 (Annals of Diagnostic Pathology), and the lowest ranking was 0 (World Journal of Clinical Cases). The average change of each journal's SJR from 2012 to 2022 was +0.11.

The median 2022 SJR of each medical student publication over time is shown in Figure 2. The median SJR increased from 2012 to 2022 (0.470 to 0.630, p=0.0002). The proportion of articles published in each journal quartile is shown in Table 1. There was no significant increase in the proportion of articles that were published in a top quartile (Q1) journal from 29% in 2012 to 41% in 2022 (p=0.09).

For citations, 4,514 articles were automatically linked to the Semantic Scholar database, leaving 667 that required manual extraction. A total of 5,172 articles were found in the Semantic Scholar database after manual review. The median number of citations by year is shown in Figure 3. There were zero citations for 1,199 (23.1%) articles. The number of publications with zero citations over time is shown in Supplemental Figure 2.

After the pilot manual review of ten articles' designs, the three reviewers (BE, ZG, and ES) were in complete agreement on study designs except for one article. This yielded an excellent kappa of 0.92 (CI 0.74-1.00). The proportion of medical student publications categorized by study design is shown in Table 2. Notably, the proportion of perspective articles increased from 6% in 2012 to 23% in 2022 (p=0.002), and the proportion of case reports decreased from 26% in 2012 to 14% in 2022 (p=0.02).

The journals with the top 100 most medical student publications during the study period published 3,476 (67%) of the total publications. Of these journals, 27 (27%) had a mandatory submission or publication cost listed on their website. The frequency of publications in these most common 100 journals with associated costs is shown in Supplemental Figure 3. Notably, the frequency of publishing in one of these journals with associated costs increased from 2012 – 3.7% to 2022 – 14.8% (p=0.02). The dataset with journal costs and publication counts is available in Supplementary File 2.

DISCUSSION

Previous evaluation of patterns and trends in

medical student research by Wickramasinghe et al. found that the number of medical student publications dramatically increased from the 1990s to 2012 [9]. Using similar methodology, we found that the dramatic increase in medical student publications continues, starting with under 100 articles/year in 2012 and increasing about tenfold by 2022.

It is important to note that our methodology likely underestimates total medical student research productivity, as not all medical student authors may have listed themselves as such during publication. However, National Resident Matching Program data, institutional-level analysis, and analyses of medical student authorship among specific journals that closely track author affiliations also show significant increases in medical student authorship over recent decades, suggesting that these findings truly represent increased medical student publications rather than increased reporting of medical student affiliations [12-16]. While the growth in the quantity of medical student research is unequivocal, whether there has been a change in quality is unclear.

There was a small but statistically significant increase (0.16) in the median SJR of journals publishing medical student research. The magnitude of this change is likely not sufficient to translate into substantial differences in the caliber of an academic journal.

In contrast, citation metrics decreased during the study timeframe. Our results demonstrated a decrease in the median times cited and an increase in the proportion of articles cited zero times, yielding a total of 23.1% of articles that were not cited a single time. Additionally, while there was an increase in perspective-type articles, there was no increase in interventional studies, prospective observational studies, or retrospective cohort studies.

Taken together, these findings suggest an overall inflation in the quantity of medical student research that emphasizes the economic principle of Goodhart's law – that when a measure becomes a target, it ceases to be a good measure [7,8]. The applicability of Goodhart's law has been demonstrated across scientific research broadly [17]. Regarding medical education in particular, publication quantity has been associated with selection into more competitive residencies [18-20]. In this situation, Goodhart's law suggests that targeting a specific research metric (i.e., quantity of publications) results in that measure no longer adequately representing the construct it was intended to assess.

This principle is particularly relevant to medical students whose research productivity can determine professional opportunities. According to self-determination theory, this rewards system drives extrinsic motivation, which can reduce the more desirable intrinsic motivation to conduct research [21]. There are many other downsides to excessive publication pressure, including associated risk for scientific misconduct [22-23], over-proliferation/flooding of literature [24], and the creation of an environment that emphasizes publishing over quality research [25]. It also encourages a system of pay-to-publish. As shown here, medical students have increasingly published their work in journals with article publication costs. Although this was a secondary hypothesis with preliminary data, it highlights important implications that require further research, such as the frequency with which institutions versus medical students are paying for these publications. Inadequate financial assistance is already reported as a main barrier for medical student research [26]. If these rising

article-processing charges are often covered by medical students, the trend could further increase disparities among students who are underrepresented, financially constrained, and attend smaller schools with less research funding.

Publishing scientific papers has benefits for medical students. Even mandatory medical research can foster beneficial mentorship and improved knowledge of research practices [27]. Research experiences can impact the specialty choices of students [28,29], improve their ability to evaluate research literature [30], and improve students' attitudes toward research [31,32]. Thus, research can be substantially beneficial to medical students.

However, our results demonstrate dramatic inflation in medical student research publications, a disproportionate rise in perspective articles, a lack of improvement in research quality, and an increase in medical student research in pay-to-publish journals. These are considerable costs that might outweigh the benefits of medical student research. But these costs are not inescapable. Strategies such as using logic models to refocus incentives on different behaviors or avoiding overreliance on quantification could help mitigate this runaway research arms race [33]. Methods to quantify and integrate research quality also show promise in minimizing a quantity focus [34].

Until new measures are taken, our results support a trend observed for nearly a century, reminiscent of the first appearance of the phrase "publish or perish" in 1928. In that same work, Clarence Case lamented, "…writings have always tended to be more voluminous than valuable, and closer examination will suggest that this tendency is becoming more pronounced within the last few years [1]."

Limitations

The primary limitation of this study is the necessary reliance on self-reported medical student status to identify medical student-authored articles. We queried PubMed for author affiliations that included the phrase "medical student", then subsequently removed articles with an affiliation that indicated that the author was not a student (i.e., Director of the Office of Medical Students). The method relies on keywords and phrasing, which are an imperfect way of filtering for medical student status. Listing one's status as a medical student is also a discretionary act and will not capture all medical student authors. Although our findings could be explained by a systematic increase in medical students choosing to identify themselves as such when submitting publications, we can think of no credible reason why this would occur.

Additionally, we limited our analysis to medical student-authored publications listed in PubMed. Not all biomedical journals meet the standards for PubMed indexing, so our findings likely again underestimate the total number of medical student-authored publications (and overestimate their quality). However, our approach is easily reproducible and modeled on previous literature [9]. Further, the veracity of our main finding – that student-authored publications have increased substantially – may be more convincing given our conservative analytic approach.

We chose to analyze publications between 2012 and 2022 because the study by Wickramasinghe et al. concluded in 2012, and we set out to analyze the publications since that study. Our timeframe concluded in 2022 because we analyzed complete years and started data extraction in 2023. One notable limitation to this timeframe is that in 2021, the United States Medical Licensing Exam (USMLE) Step 1 planned to transition to pass/fail scoring at the beginning of 2022, which could have affected the

research activities of medical students. Further research is needed to specifically explore the impact of the USMLE Step 1 pass/fail transition on medical student research trends.

Although we considered citation counts, study design, and journal rankings as measures of publication quality, we acknowledge the inherent limitations of using these – or any other – measures in isolation to determine research quality. SJRs rely on the Scopus database, which does not encompass the entire scientific literature. SJRs and citation counts are also subject to citation padding and coercive citations, practices where authors and journals skew citations to improve their research metrics [22,35]. Citation counts are also subject to other issues when suggesting quality, including the fact that popularity does not equal quality, some citations may refute the cited article's results, different medical disciplines may have more frequent citations, and they are dependent on the time available for citation.

Finally, while our study demonstrates growth of PubMed research articles by medical students and publications with article-processing charges, the trends specifically among medical students cannot be separated from the global research growth. Research in general is growing, including articles published, open-access journals with article-processing charges, journals on PubMed, and more [36]. Thus, whether the growth in medical student metrics is specifically attributable to motivational pressures versus a much broader growth in research is difficult to determine.

CONCLUSION

Between 2012 and 2022, the quantity of medical student research on PubMed has dramatically increased, with a particular increase in perspective pieces and publications in journals with publication costs. These findings suggest that medical student research is rapidly growing in quantity without proportional gains in quality.

ARTICLE INFORMATION

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Year	Q1	Q2	Q3	Q4	Not Ranked
2012	26%	17%	48%	0%	9%
2013	25%	17%	36%	2%	23%
2014	32%	21%	27%	2%	20%
2015	37%	18%	21%	6%	24%
2016	31%	17%	30%	4%	22%
2017	32%	20%	29%	4%	19%
2018	30%	24%	27%	5%	20%
2019	41%	25%	24%	4%	10%
2020	40%	21%	25%	6%	14%
2021	43%	19%	25%	5%	13%
2022	39%	24%	21%	3%	16%

Table 1. The proportion of medical student PubMed articles published in each SJR quartile from 2012 to 2022.

Study Design	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Case control	7%	4%	3%	4%	2%	2%	2%	2%	1%	1%	1%
Case report	26%	15%	19%	16%	16%	17%	21%	15%	11%	12%	14%
Cross-sectional	15%	21%	18%	16%	16%	14%	14%	19%	16%	15%	16%
Interventional trial	2%	5%	4%	2%	3%	2%	2%	1%	2%	2%	2%
Laboratory experimentation	6%	5%	5%	4%	6%	3%	4%	3%	4%	2%	3%
Medical education intervention	2%	6%	5%	4%	8%	10%	6%	8%	8%	9%	9%
Other	0%	4%	2%	2%	3%	2%	2%	1%	4%	4%	2%
Perspective, commentary, or letter	6%	16%	16%	17%	13%	20%	14%	20%	26%	27%	23%
Prospective observational	9%	5%	5%	6%	5%	4%	5%	3%	3%	3%	3%
Retrospective cohort	7%	8%	11%	16%	12%	13%	11%	13%	10%	10%	10%
Review	20%	10%	12%	13%	15%	13%	18%	16%	13%	14%	16%

Table 2. The proportion of medical student publications categorized by study design from 2012 to 2022.

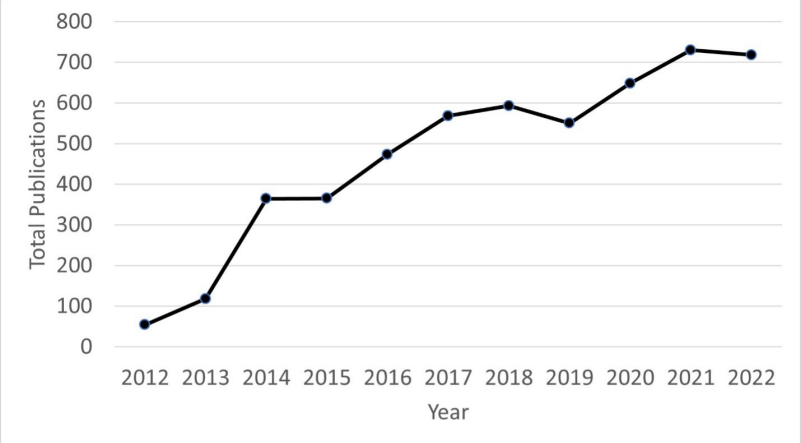

Figure 1. Total medical student-authored, PubMed-indexed publications from 2012 to 2022.

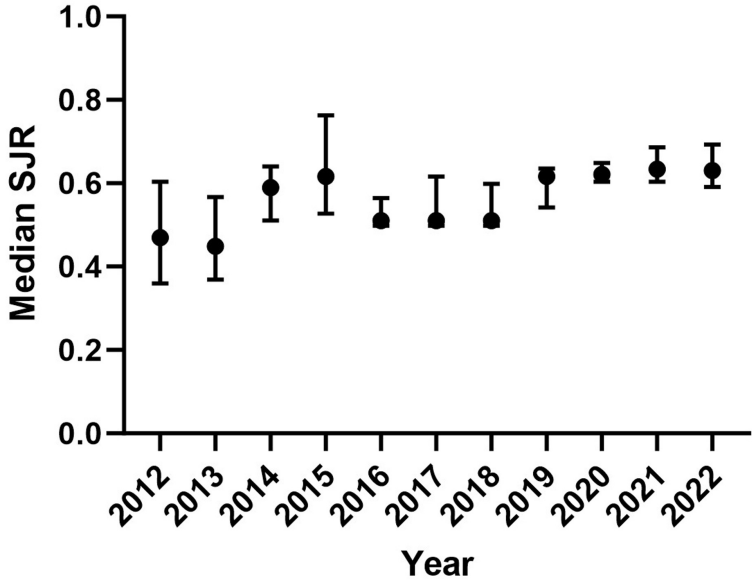

Figure 2. Median Scimago Journal Ranking of medical student publications by year, with dots representing the median and bars representing the 95% confidence intervals.