A Decade in Print: The Evolving Academic Benchmark of Cardiology Fellowship Applications

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Article

A Decade in Print: The Evolving Academic Benchmark of Cardiology Fellowship Applications

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Abstract: Research output has become an increasingly important criterion for competitive fellowship applications. While prior studies have quantified this trend in other specialties, the same has not been done for cardiology fellowships. This retrospective cohort study included cardiology fellows from two cohorts, ten years apart, at 10 of the top 25-ranked U.S. cardiology programs selected from Doximity's reputation rankings. PubMed was utilized to quantify research output prior to fellowship entry. Primary outcomes were total publications, first-author publications, and cardiology-related ("in-specialty") publications. Among 155 fellows (72 in 2017; 83 in 2027), the mean total number of publications increased from 2.67±3.22 in 2017 to 7.18±9.34 in 2027. First-authorships increased from 1.35±2.25 to 2.54±3.30, and in-specialty publications rose from 1.79±2.90 to 4.81±8.58. Logistic regression showed that the 2027 cohort was significantly more likely to have ≥1 publication (OR 2.3 [95% CI, 1.14–3.50]; p<0.001). Degree type, institutional transitions, and geographic mobility were not significant predictors. Cardiology fellowship applicants in 2027 had markedly higher research output compared to the class of 2017, indicating a growing emphasis on scholarly productivity in the selection processes. These findings raise questions about equitable access to research opportunities and the potential emergence of barriers to scholarly output among aspiring cardiologists.

Keywords: cardiology; fellowship; research; equity; scholarly output

1. Introduction

The pathway to becoming a board-certified cardiologist has always been a competitive process. The prestige of the field, earning potential, and relatively limited number of fellowship positions lend to its rank as one of the most competitive internal medicine sub-specialties [1]. Historically, matching into a cardiology fellowship has required top United States Medical Licensing Exam (USMLE) scores, letters of recommendation, and research experience to select the most qualified applicants. The need for applicants to distinguish themselves and improve their chances of acceptance has subsequently led to prioritizing a specific part of the application: research. It is the aspect of an applicant's portfolio that demonstrates critical thinking skills and determination, which effectively sets an applicant apart in an increasingly competitive pool of qualified individuals. As a result, applicants across multiple competitive specialties have increased their research output accordingly. The average number of pre-residency publications increased from 2.6 in 2011 to 6.5 in 2018 for neurosurgery, 3.0 in 2007 to 6.7 in 2014 for orthopedic surgery, and 1.6 in 2007 to 4.7 in 2018 for dermatology highlighting this shift in the application process [2–4].

Similarly, cardiology fellowship has also remained competitive, indicated by its 66% match rate in 2021 compared to 65% in neurosurgery [5,6]. These findings raise an important question about the state of the cardiology application process. With a general trend towards an increase in publications in other competitive specialties, has the trend for cardiology fellowship applicants also changed to meet an elevated research benchmark?

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This study aimed to determine if first-year cardiology fellows in the class of 2027 from 10 of the top 25 cardiology fellowship programs had significantly different research outputs prior to matriculation than fellows a decade ago. We hypothesized that cardiology fellows in the class of 2027 would have higher research output compared to those in the class of 2017. To test this hypothesis, we compared cardiology fellows in the class of 2027 to fellows in the class of 2017. Differences in total publications, first authorships, and in-specialty (cardiology-related) publications were assessed. Further, regional and institutional changes were included to see how research output may change as professionals build deeper roots and connections in one place. We predicted that trainees who stayed at one institution may be more academically productive than those who moved during training. Through the assessment of these factors, this project aims to determine whether there has been a shift in research publication output within the past decade and what factors may affect this change.

2. Materials and Methods

2.1. Study Design

A retrospective, observational analysis was conducted of cardiology fellows entering training at two distinct periods: Class of 2017 (Phase 0) and the Class of 2027 (Phase 1). The primary analysis was designed to focus on publication output changes over ten years in the PGY4 cardiology classes in Phases 0 and 1, including total publication volume, first authorship, and in-specialty publications. The secondary analysis assessed changes in publication output based on AAMC-defined national regions and institutional changes between the two cohorts [7].

2.2. Program and Fellow Selection

Using Doximity Residency Navigator, fellowship programs were filtered using "Internal Medicine," selected for "Your Specialty," and "Cardiovascular Disease," selected as "Intended Fellowship." Programs were then sorted by "Reputation" [8]. From the top 25 programs, 10 were selected that provided adequate historical data for both Phase 0 and Phase 1 fellows.

This historical data included the following publicly available information: (1) fellow's full name; (2) fellow's degree (MD only, MD/PhD, or International Medical Graduate [IMG]); and (3) fellow's medical school and residency programs. If the medical school or residency programs were unavailable on the program website, individual fellows were searched on Doximity to identify missing information under "Education & Training." If these data could not be identified for all cohort members, then the next program on Doximity was selected, depending on the reputation.

After applying inclusion/exclusion criteria, fellows were organized into cohorts with further subdivisions (Table 1).

Table 1. Descriptive Comparison of Cardiology Fellowship Cohorts (Class of 2017 and 2027).

	Total Fellows (n)	MD Only (n, %)	MD/PhD (n, %)	IMG (n, %)
Class of 2017	72	60 (83.3%)	3 (4.2%)	9 (12.5%)
Class of 2027	83	67 (80.7%)	9 (10.8%)	7 (8.4%)

2.3. Publication History

Publication output was determined once fellows were divided into Phase 0 and Phase 1 cohorts with their respective categorical data. Each fellow was searched on PubMed under advanced filter settings. Search settings included "Affiliation" and "Author" names, starting with medical school and then residency. For Phase 0 fellows, the upper limit for the year of publication was set to "2014" to prevent capturing publications after the fellowship began. Once publications were gathered, each was reviewed to ensure names and affiliations matched to the fellow of interest. In-specialty publications were then determined by reviewing each publication's title and scope. Finally, total publications, first authorships, In-Specialty publications, Journal Publications, and digital object

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identifier (DOI) were tabulated into a Google Sheets spreadsheet for data analysis. Impact factor was not considered in this study due to the changing nature of this metric over a 10 year period.

2.4. Regional and Institutional History

After publication data, each fellow's medical school, residency, and fellowship programs were organized based on AAMC geographic regions (Table 2).

Changes in the geographic region and institutions through career transitions were determined and documented.

Table 2. States divided into AAMC Regions.

Region	States
New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic	New Jersey, New York, Pennsylvania
East North Central	Illinois, Indiana, Michigan, Ohio, Wisconsin
West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
South Atlantic	Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, Puerto Rico, South Carolina, Virginia, West Virginia
East South Central	Alabama, Kentucky, Mississippi, Tennessee
West South Central	Arkansas, Louisiana, Oklahoma, Texas
Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific	Alaska, California, Hawaii, Oregon, Washington

2.5. Fellow and Publication Metrics

Fellow metrics included phase (Class of 2017 or Class of 2027), degree (MD only, MD/PhD, IMG), institution change (medical school to residency, residency to fellowship) and geographic region changes based on AAMC regions (medical school to residency, residency to fellowship). Publication metrics included the number of total publications, the number of first-author publications, and the number of cardiology-related (in-specialty) publications.

2.6. Statistical Analysis

All analyses were performed using Python 3.10.12. We calculated descriptive statistics to summarize each fellow's total publications, first-author publications, in-specialty publications, and changes in institution or geographic region. Continuous variables (e.g., publication counts) were presented as means, medians, and standard deviations (SD), while categorical variables (e.g., degree type, institutional changes) were reported as counts and percentages.

Nonparametric tests (Mann–Whitney U or Kruskal–Wallis) were applied where data were not normally distributed; otherwise, Welch's t-tests were used. Spearman's rank correlation coefficients were computed to assess relationships among publication metrics and degree type. We performed chi-square or Fisher's exact tests for categorical comparisons. Stratified analyses examined differences by degree type (MD, MD/PhD, IMG), and geographic or institutional mobility patterns were compared between cohorts.

Finally, logistic regression models evaluated the probability of having ≥1 publication based on phase (Phase 0 vs. Phase 1), degree type, and region/program transitions. All p-values were two-sided, with $p<0.05$ deemed significant. The Python scripts used in this analysis are available upon request, ensuring reproducibility. No adjustments were made for multiple comparisons.

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2.7. Ethical Considerations

The study utilized publicly available data and did not involve direct contact with institutions, fellows, or attending physicians. Therefore, institutional review board (IRB) approval was not required. Nevertheless, all data were handled in compliance with ethical research standards to protect individual privacy.

Because individual-level data were derived from publicly accessible information, there are no privacy concerns. However, the dataset compiled and used for this analysis will not be made publicly available to avoid potential identification of individuals, but will be made available upon reasonable request. For analysis code, Python scripts used for data analysis are available upon request to ensure reproducibility.

2.8. Data Validation

All data entries were double-checked by two independent researchers. Any discrepancies were resolved through discussion and consensus. Data extraction procedures were standardized to enhance reproducibility.

3. Results

A total of 72 fellows from the Class of 2017 and 83 fellows from the Class of 2027 were identified, as shown in Table 1. The cohort demographics revealed slight shifts in degree composition, mainly an increase to 10.8% in MD/PhD fellows in the Class of 2027 compared to 4.2% in the Class of 2017. Additionally, there were minor differences in IMG representation, with 12.5% in the Class of 2017 and 8.4% in 2027. MD-only fellows represented the majority in both cohorts. When fellows of different degree status were compared in our logistical regression, these differences were rendered insignificant in terms of probability producing one publication as evidenced in Table 3.

Table 3. Logistical Regression Model for Probability of ≥1 Publication.

Predictor	Coefficient	Std. Error	z-value	p-value	95% CI [Lower, Upper]
Intercept	0.8412	0.596	1.410	0.158	[<0.01, 2.010]
Phase 1 vs Phase 0	2.3217	0.603	3.853	0.000	[1.141, 3.503]
MD/PhD vs MD	-0.3802	0.947	-0.401	0.688	[<0.01, 1.477]
IMG vs MD	0.7478	0.866	0.864	0.388	[<0.01, 2.445]
Region Change (Medical School to Residency)	0.3837	0.661	0.580	0.562	[<0.01, 1.680]
Region Change (Residency to Fellowship)	-0.3904	0.935	-0.418	0.676	[<0.01, 1.442]
Institution Change (Medical School to Residency)	-1.0441	0.806	-1.296	0.195	[<0.01, 0.535]
Institution Change (Residency to Fellowship)	1.2733	0.890	1.430	0.153	[<0.01, 3.019]

3.1. Combined Publication Analysis

The comparative analysis showed noteworthy changes in research output metrics over time. Table 2 identifies these changes. Across all fellows, mean total publications rose from 2.67 ±3.22 in the 2017 class to 7.18 ±9.34 in 2027 ($p<0.05$). First-authorships increased from a mean of 1.35 ±2.25 to 2.54 ±3.30 ($p<0.05$). Similarly, in-specialty publications rose from 1.79 ±2.90 to 4.81 ±8.58 ($p<0.05$).

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Among the degree types (MD, MD/PhD, IMG), MDs showed a significant reduction in those with no publications between the two cohorts, going down from 18 to 4 ($p<0.05$, Table 4).

Table 4. Non-publishers by Degree and Phase.

Non-publishers Degree	Class of 2017	Class of 2027	Fisher's p-value
MD	18	4	0.00037
MD/PhD	2	0	0.045
IMG	2	0	0.475

3.2. Subgroup Analysis

MD/PhD fellows showed an increase in total, first-author and in-specialty publications, though sample sizes were small (Table 5). Similarly, IMG fellows showed a significant increase in total and first-author publications with no significant change in in-specialty publications (Table 5).

Table 5. Comparative Analysis of Research Output Metrics by Cardiology Fellowship Cohorts (Class of 2017 and 2027).

	Class of 2017	Class of 2027	*p*-value
Total Fellows	n= 72	n=83	
Total Publications (mean ±SD)	2.67 ± 3.22	7.18 ± 9.34	<0.001
First-Authorships (mean ±SD)	1.35 ± 2.25	2.54 ± 3.30	<0.001
In-Specialty Publications (mean ±SD)	1.79 ± 2.90	4.81 ± 8.58	$<0.001^{-5}$
MD Fellows	n=60	n=67	
Total Publications (mean ±SD)	2.37 ± 2.90	6.19 ± 9.67	<0.001
First-Authorships (mean ±SD)	1.27 ± 2.31	2.27 ± 3.40	<0.001
In-Specialty Publications (mean ±SD)	1.58 ± 2.81	4.12 ± 8.81	<0.001
MD/PhD Fellows	n=3	n=9	
Total Publications (mean ±SD)	0.67 ± 1.15	11.33 ± 2.40	0.01
First-Authorships (mean ±SD)	0.67 ± 1.15	3.67 ± 1.73	<0.01
In-Specialty Publications (mean ±SD)	0.00 ± 0.00	8.44 ± 6.21	<0.01
IMG Fellows	n=9	n=7	
Total Publications (mean ±SD)	5.33 ± 4.39	11.29 ± 9.91	0.03
First-Authorships (mean ±SD)	2.11 ± 2.09	3.71 ± 3.64	0.04
In-Specialty Publications (mean ±SD)	3.78 ± 3.23	6.71 ± 8.52	>0.99

3.3. Predictors of Publication Status

In the multivariable logistic regression model predicting the odds ratio of having one or more publications, only the cohort was a positive predictor. Compared to the 2017 cohort, members of the 2027 cohort were more than twice as likely to have at least one publication (OR 2.3 [1.141, 3.503]). Degree type, changes in geographic region from medical school to residency and institutional transitions from medical school to residency and residency to fellowship were not predictors of having publications (data not shown).

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4. Discussion

4.1. Research Output, Equity, and Resource Distribution

In this retrospective, observational study of cardiovascular fellows from 2017 to 2027, we noted a significant increase in research productivity. This included all publications, first-author publications and cardiology-specific publications. This finding is in agreement with findings from other medical subspecialties, including gastroenterology, hematology, endocrinology, and nephrology [9,10]. To our knowledge, this is the first study to examine research output trends in cardiovascular fellows. These findings highlight a profound evolution in the publication environment for incoming cardiology fellows.

Our findings show that contemporary cardiovascular fellows have more scholarly productivity than those just a decade ago. An increase in in-specialty publications and first-authorships may represent trainees immersing themselves in focused inquiry, dedicating time to developing their clinical questioning, and assertively taking the lead on projects. The impetus behind this change may reflect a genuine commitment to understanding and improving the scientific foundation of cardiovascular care. However, it is also possible that these accomplishments may simply be a measure to maintain competitiveness in the current environment. Cullen et al. identified a shift in internal medicine applicants who committed to a cardiovascular fellowship from 2014 to 2024 [1]. These findings included increased scholarly output, cardiovascular medical knowledge, and an earlier declaration of cardiovascular career intent, possibly reflecting an earlier commitment to the field. This may have implications beyond recruitment for cardiovascular fellows. As the volume of studies swells, concerns arise about the proliferation of less impactful work that clouds the literature with academic "noise" [11].

Furthermore, the increased need for productivity may inadvertently create barriers to entry for certain applicants. Institutional support for research can vary across different residencies. Factors such as time to participate in research during training, availability of mentors, and institutional funding can be dissimilar across programs [12]. Applicants from programs with fewer resources may be at a disadvantage. For applicants with less financial support than others, this could also pose an obstacle to gaining acceptance [13]. Suppose this trend of elevated publication rates continues. Resource-dependent alternatives such as research years will likely gain favor but may be out of reach for the average cardiology fellowship applicant. MD/PhDs may be better positioned to thrive amid these evolving expectations, while others may face considerable challenges. The data from this paper directly goes against this claim, but this is likely due to the limited sample size for MD/PhDs. Therefore, a conclusion can not be made regarding the MD/PhD deviation from the hypothesized pattern.

As the ever-evolving benchmarks for fellowship continue to shift toward more extensive research portfolios, competent and motivated applicants who lack these advantages may find themselves at a growing disadvantage. This raises concerns about whether applicants who face professional, logistical, or socioeconomic barriers to accessing research can navigate the intricacies of the academic landscape.

4.2. Geographic and Institutional Mobility

Although the data shows substantial increases in publication output, the pattern of geographic region and institutional mobility did not seem to be related to this rise. Theoretically, staying in one region or institution may expand and deepen the roots and networks of medical students, residents, and fellows, but the logistical regression showed no significance for this hypothesis.

4.3. Limitations

This project has inherent limitations due to its reliance on publicly available data from top-tier programs that may not generalize to all cardiology fellows. Collecting data from PubMed carries the

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risk of collecting incorrect data. In attempts to remedy this with affiliation and name matching, there may be a risk of misattribution. Additionally, only two cohorts 10 years apart do not account for the years in between, limiting the ability to confidently comment on more gradual trends. The relatively small representation of MD/PhD and IMG fellows also restricts the strength of these subgroup comparisons.

4.4. Future Research

Although this project highlights evolving trends in research output, it also raises new questions that warrant further research. As publication rates increase, we must examine whether this surge enhances or undermines the quality and impact of scholarly contributions. Due to the transition of USMLE Step 1 being scored to pass/fail, more weight will be placed on research involvement. Future studies should be done to assess the quality, relevance, and scholarly rigor of output from these cohorts.

5. Conclusions

These findings reflect on equity, mentorship, and resource distribution. As the weight of traditional metrics such as USMLE Step 1 scores diminishes, scholarly output has emerged as a pivotal cornerstone. With this rise in expectations comes an urgent call to re-evaluate the existing infrastructure that shapes early academic careers while maintaining and cultivating passionate young researchers entering the field of cardiology. It is critical to pay attention to these demands to limit the exclusion of those with fewer resources, less guidance, or limited time. By fostering equitable access to research mentorship and resources, the profession can sustain the growth in scholarly output without sacrificing the diverse talent and nuanced perspectives that enrich patient care and medical discovery.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

USMLE	United States Medical Licensing Examination
PGY	Postgraduate year
IMG	International Medical Graduate
MD	Doctor of Medicine

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AAMC Association of American Medical Colleges

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