Scholarly Productivity of US Medical Schools Before and During the COVID-19 Pandemic

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Objectives: The coronavirus disease 2019 pandemic profoundly disrupted scientific research but was accompanied by a rapid increase in biomedical research focused on this new disease. We aimed to study how the academic productivity of US medical schools changed during the pandemic and what structural characteristics of medical schools were associated with trends in scholarly publication.

Methods: Annual totals of publications for each US Doctor of Medicine–granting medical school were extracted for 2019 to 2021 from the Scopus database, and schools were categorized a priori as experiencing a sustained increase in publications, a transient increase in publications, or no increase in publications. Bivariate tests compared school characteristics among these three groups.

Results: Of 139 Doctor of Medicine–granting medical schools, 79% experienced sustained growth in publications from 2019 to 2021, 6% experienced transient growth, and 14% experienced no growth. Sustained growth in publications was associated with being affiliated with a research-intensive university, larger faculty size, the presence of an Emergency Medicine residency, having higher baseline National Institutes of Health funding, and experiencing higher coronavirus disease 2019 infection rates in the local community during the early months of the pandemic. Among predominantly White institutions, a higher diversity of female faculty was associated with a higher likelihood of experiencing transient rather than sustained growth in publications.

Conclusions: Our results demonstrate that scientific output increased during the pandemic at most medical schools, despite significant barriers to research experienced by individual investigators. Further attention is needed to enhance equity in research opportunities, considering diverging trends in productivity between more- and less-advantaged schools, however.

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The impact of coronavirus disease 2019 (COVID-19) on biomedical research has been widely debated. Some reports have emphasized an acceleration of research and publication during the pandemic because of the increase in COVID-19–specific research and acceleration of the peer review process.[1] For example, one study reported that in the first 6 months of the pandemic, COVID-19–related research was published within 19 days of submission, compared with 91 days for other work.[2] Other commentaries anticipated that the pandemic would cause a slowdown in research activity. This slowdown may have been the result of lockdowns, increased care work among faculty, and reprioritization of research funding.[3,4] This expectation has been borne out by surveys of active scientists, with a majority reporting a decrease in work hours and various challenges to pursuing their planned research.[4] Considering the long life cycle of typical research projects from conception to publication,[5] the full impact of the pandemic on scholarship may not have become apparent until recently. Moreover, the pandemic may have differentially affected research productivity depending on organizational priorities and support for biomedical research available at each institution.

Research and scholarship opportunities are highly stratified in academic medicine. Even before the pandemic, there was a significant disparity among medical institutions in publications and research funding. Just 10 Doctor of Medicine (MD)–granting medical schools in the United States account for nearly 30% of research funding disbursed by the National Institutes of Health (NIH).[6] These disparities are related to differences in institutional missions, availability of research resources, and history

Key Points

- Scholarly productivity increased during the course of the coronavirus disease 2019 pandemic at most medical schools, despite significant barriers to research experienced by individual investigators.
- Of 139 Doctor of Medicine–granting medical schools, 79% experienced sustained growth in publications from 2019 to 2021; 6% experienced transient growth and 14% experienced no growth.
- Trends in scholarly output during the coronavirus disease 2019 pandemic threaten to widen the disparity among medical schools.

of success with funding and scholarship.[7,8] Furthermore, institutional disparities in research productivity intersect with individual-level differences in research participation among faculty in academic medicine. For example, faculty in primary care departments may be more likely to hold non–tenure-track appointments and have less time and fewer resources to pursue scholarly work.[8] In addition, disparities in research productivity and grant funding disparities exist along gender and racial/ethnic lines, with female faculty and faculty from groups underrepresented in medicine (UIM) publishing disproportionately fewer works and receiving disproportionately less extramural funding support.[7,9–11]

In the United States, well-resourced, research-focused medical schools may have been best positioned to lead the wave of novel COVID-19–related research while sustaining and expanding their existing research agenda. For example, a recent analysis showed that only 25% of US MD-granting medical schools participated in registered pediatric COVID-19 clinical trials, with schools in this group tending to have high levels of federal funding and publication output prepandemic.[12] Conversely, institutions with fewer resources may have had fewer opportunities to participate in COVID-19–related research and may have encountered more obstacles to maintaining faculty scholarly productivity. In this study, we aimed to determine how many and which US medical schools experienced sustained growth of scholarly productivity during the pandemic, compared with transient increases in scholarly productivity or the decline in scholarly output that some commentators had anticipated. We hypothesized that at a minority of well-resourced US MD-granting medical schools, the onset of the COVID-19 pandemic was followed by a sustained acceleration of research productivity, whereas at the majority of medical schools, scholarly publication increased transiently or declined throughout the pandemic era to date.

Methods

This study used institution-level aggregate data and publicly available bibliographic records, and did not incorporate human subjects research. A list of US MD-granting medical schools was obtained from the Association of American Medical Colleges (AAMC) Web site. Medical schools that could not be identified in the Scopus bibliographic database were excluded from the analysis.[12] The Scopus database was queried by affiliation in January 2022 to determine the number of publications associated with each medical school in the calendar years 2019, 2020, and 2021. The primary outcome was a categorical measure of change in publication productivity during the pandemic. A priori, we defined publication trajectory as a sustained increase (an increase from 2019 to 2020 and from 2020 to 2021), a transient increase (an increase from 2019 to 2020, followed by no change or decrease from 2020 to 2021), and no increase (same or fewer publications in 2020 as compared with 2019). As a secondary outcome, we examined the percentage increase in publications in 2021 compared with 2019 among schools in the sustained increase group. In an exploratory analysis, we queried the number of publications matching a previously described set of COVID-19–related key words[12] among the 10 schools experiencing the fastest publication growth to characterize the contribution of COVID-19–specific research to this increase in scholarly productivity.

Independent variables were primarily assessed as of 2019 to coincide with the baseline of our data collection period. These variables included medical school type (public vs private), school location (based on US Census region), school ranking in the *US News and World Report* top 10, NIH funding in 2019, number of full-time faculty in 2019, faculty diversity, and the ratio of full-time faculty to total enrollment in the academic year 2019–2020. School type, location, ranking, and NIH funding data were obtained from a previous study.[12] The number of faculty and data on faculty diversity were obtained by a custom query from the AAMC Faculty Administrative Management Online User System database.[13] Among predominantly White institutions (PWIs), faculty diversity was categorized based on the percentage of faculty identifying as members of UIM groups, grouped into tertiles. Historically Black colleges and universities (HBCUs) and medical schools in Puerto Rico were analyzed as a separate group because these institutions have a significantly higher representation of UIM faculty than PWI medical schools. Faculty diversity was assessed for the entire school and stratified by faculty gender because of the likely impact of gender on changes in scholarly productivity during the pandemic.[14] Medical school enrollment data were obtained from the AAMC based on historical tables from the FACTS report.[15]

Additional independent variables were obtained to provide further information on research capacity and the impact of the pandemic on each medical school. The presence of home residency programs in Emergency Medicine, Family Medicine, and Internal Medicine was queried from the National Resident Matching Program, representing specialties at the frontline of the pandemic response.[16,17] AAMC FACTS data also were used to determine whether each school offered a MD/Doctor of Philosophy combined degree program, based on whether any students were enrolled in such a program as of 2019. Medical school affiliation with a research-intensive (Carnegie classification R1) university was queried to reflect differences in schools' opportunity to draw on the research resources of a larger university system.[18] Lastly, we queried the early impact of the pandemic on the counties in which each medical school was located to determine how exposure to the early wave of COVID-19 infections shaped medical schools' subsequent scholarly productivity trajectory. Early COVID-19 impact was defined as the modeled peak monthly infection rate per 100,000 people during March to May 2020, as reported in the covidestim database.[19]

Data were summarized as medians with interquartile ranges or counts with percentages. School characteristics were compared across the prespecified categories of scholarly productivity using Kruskal-Wallis or Fisher exact tests, as appropriate. Among schools in the sustained increase category, the association between each covariate and the rate of scholarly productivity growth was

Table 1. Number of Scopus-indexed publications in each calendar year (median and IQR) by medical school pattern of scholarly productivity during the COVID-19 pandemic (N = 139 schools)

Year	Schools with sustained increase in publications, n = 110 (IQR)	Schools with transient increase in publications, n = 9 (IQR)	Schools with no increase in publications, n = 20 (IQR)
2019	548 (194–1585)	184 (101–265)	187 (52–668)
2020	690 (256–1759)	236 (106–299)	184 (50–630)
2021	895 (354–2307)	232 (87–276)	232 (99–776)

COVID-19, coronavirus disease 2019; IQR, interquartile range.

assessed using quantile regression. Multivariable analysis could not be used because of substantial collinearity among study variables.[12] Data analysis was completed using STATA/SE 16.1 (StataCorp, College Station, TX), and $P < 0.05$ was considered statistically significant.

Results

We identified 139 medical schools meeting inclusion criteria, 110 (79%) of which demonstrated sustained growth in scholarly productivity, 9 (6%) demonstrated transient growth, and 20 (14%) demonstrated no growth. The number of publications in each year was compared across these three groups in Table 1. At the 2019 baseline, schools that experienced sustained growth already had the highest annual number of publications (median of 548 vs 184 and 187 among schools experiencing transient and no growth, respectively). Sustained publication growth, however, was not restricted to schools with significant academic productivity at baseline; 25% of schools in this category had <195 publications in 2019 and 5% had <50 publications. Among schools experiencing sustained growth in productivity, the median increase in annual publications from 2019 to 2021 was 49% (interquartile range 34%–88%). Focusing on the 10 schools with the fastest rate of increase (>168% gain comparing 2019 with 2021), we found that COVID-19–related publications in 2021 accounted for only 6% to 19% of the increase (median 12%).

Table 2 presents comparisons of institutional characteristics among schools experiencing sustained growth, transient growth, or no growth in scholarly productivity during the pandemic. As expected, higher research capacity (defined by higher baseline NIH funding and affiliation with an R1 university) was favorably associated with sustained growth in scholarly productivity. Larger faculty size (defined by a higher number of faculty or faculty:student ratio) also was associated with sustained growth in publications. Considering the available residency programs, the presence of an Emergency Medicine program, but not Family Medicine or Internal Medicine, was associated with a sustained increase in publications. Census region, *US News and World Report* top 10 ranking, and dual-degree program availability were not significantly associated with the trend in scholarly productivity (although 9 of the schools ranked in the top 10 were classified in the sustained increase group).

Results for faculty diversity differed by sex. Diversity among the overall faculty and diversity among male faculty were not associated with the trend in scholarly productivity. A high level of diversity among female faculty at PWIs was associated with transient growth in publication productivity, as compared with sustained growth or no growth. Notably, all three HBCU medical schools experienced no growth in scholarly productivity, as defined in our study. When considering the early impact of the pandemic, schools experiencing sustained growth in scholarly productivity tended to be located in areas with higher infection rates during March to May 2020. Within the group of schools experiencing sustained growth in scholarly productivity, none of the independent variables were associated with the percentage change in publications from 2019 to 2021 (Table 3).

Discussion

The COVID-19 pandemic was predicted to profoundly disrupt non-COVID-19–related research because of the prioritization of COVID-19 studies, difficulties with consenting study participants in person, reallocation of funds, institutional shutdowns, and stay-at-home orders.[20–24] The work of many research groups, especially basic science laboratories and clinical trials requiring in-person research activities, was halted abruptly.[23,24] Nevertheless, the biomedical research community demonstrated increased collaboration and scholarly productivity during the pandemic, and the growth in the publication of COVID-19–related research made up for short-term declines in research output unrelated to the pandemic.[24–27] For physician faculty, the combination of research restrictions with increased clinical workload may have especially hindered participation in research and scholarly activity, regardless of the topic. Although recent survey studies have found that physician faculty self-reported decreases in academic productivity,[28,29] our study found that among US medical schools, most of the institutions were able to sustain growth in the number of publications from 2019 through 2021. Furthermore, we identified structural factors related to research capacity, faculty diversity, and the impact of the pandemic that may have contributed to differing trends in scholarly productivity among medical schools during this time. The juxtaposition of research barriers reported by individual faculty during the pandemic and sustained (but unequal) research growth among medical schools suggest that greater attention is needed to ensure equitable access to scholarship opportunities for faculty and trainees within academic medicine.

Research conducted before the COVID-19 pandemic identified various individual and institutional barriers to scholarly

Table 2. Medical school characteristics (median and IQR or count and percentage) by medical school pattern of scholarly productivity during the COVID-19 pandemic (N = 139 schools)

Variable	Schools with sustained increase in publications, n = 110 (IQR)	Schools with transient increase in publications, n = 9 (IQR)	Schools with no increase in publications, n = 20 (IQR)	*P*
School type				0.072
Private	42 (38)	1 (11)	11 (55)	
Public	68 (62)	8 (89)	9 (45)	
Census region				0.157
Northeast	25 (23)	1 (11)	4 (20)	
Midwest	29 (26)	1 (11)	3 (15)	
South	34 (31)	7 (78)	11 (55)	
West	19 (17)	0	1 (5)	
PR	3 (3)	0	1 (5)	
No. faculty	1104 (653–1925)	353 (248–446)	719 (230–1105)	<0.001
Faculty:student ratio	1.9 (1.0–2.7)	0.8 (0.7–1.1)	0.9 (0.5–1.7)	<0.001
Residency programs				
Emergency Medicine	88 (80)	4 (44)	14 (70)	0.037
Family Medicine	89 (81)	6 (67)	15 (75)	0.420
Internal Medicine	108 (98)	9 (100)	18 (90)	0.192
Faculty diversity, all faculty (%)				0.147
PWI, lowest tertile	36 (33)	2 (22)	6 (30)	
PWI, middle tertile	35 (32)	3 (33)	6 (30)	
PWI, highest tertile	36 (33)	4 (44)	4 (20)	
HBCU and PR	3 (3)	0	4 (20)	
Faculty diversity, women (%)				0.035
PWI, lowest tertile	36 (33)	3 (33)	5 (25)	
PWI, middle tertile	35 (32)	1 (11)	8 (40)	
PWI, highest tertile	36 (33)	5 (56)	3 (15)	
HBCU and PR	3 (3)	0	4 (20)	
Faculty diversity, men (%)				0.079
PWI, lowest tertile	34 (31)	3 (33)	7 (35)	
PWI, middle tertile	39 (35)	2 (22)	3 (15)	
PWI, highest tertile	34 (31)	4 (44)	6 (30)	
HBCU and PR	3 (3)	0	4 (20)	
NIH funding, $M	16 (0–119)	0 (0–2)	6 (0–32)	0.042
USNWR top 10 ranking (%)	10 (9)	0	1 (5)	>0.999
Combined degree program (%)	88 (80)	6 (67)	13 (65)	0.196
R1 university affiliation (%)	77 (70)	4 (44)	9 (45)	0.038
Peak COVID-19 infection rate per 100,000 people in county	852 (228–2610)	87 (40–463)	367 (161–1392)	0.017

COVID-19, coronavirus disease 2019; HBCU, historically Black colleges and universities; IQR, interquartile range; NIH, National Institutes of Health; PR, Puerto Rico; PWI, predominately White institution; R1, research intensive; USNWR, US News and World Report.

productivity in academic medicine. For example, Black scientists were found to have a lower likelihood of receiving R01 awards from the NIH than White scientists,[30] whereas women, as compared with men, have been underrepresented as authors in the biomedical scientific literature.[24,31] For individual faculty at medical schools, higher clinical workloads and administrative responsibilities pose significant barriers to research participation.[32] At the same time, faculty appointment to non-tenure-earning tracks also is correlated with lower research productivity than tenure-track appointments.[8] Faculty at medical schools also may experience barriers to research that differ by specialty, with Primary Care and especially Family Medicine faculty exhibiting lower academic productivity than faculty in other departments.[8,33] At the institutional level, larger centers, particularly centers with a higher number of residents, tend to exhibit higher scholarly productivity,[32,34] as do medical schools with higher levels of

Table 3. Unadjusted quantile regression models of percentage growth in number of publications, 2019–2021, among medical schools experiencing sustained increase in scholarly productivity (N = 110 schools)

Variable	Coefficient[a]	95% CI	*P*
School type			
Private	Ref.		
Public	9.6	−10.1 to 29.4	0.336
Census region			
Northeast	Ref.		
Midwest	15.8	−26.4 to 57.9	0.460
South	17.2	−23.5 to 57.9	0.404
West	17.9	−29.1 to 64.9	0.452
PR	91.9	−2.5 to 186.2	0.056
No. faculty	−0.004	−0.010 to 0.002	0.221
Faculty:student ratio	−2.4	−7.9 to 3.1	0.393
Residency programs			
Emergency Medicine	−4.2	−29.9 to 21.4	0.743
Family Medicine	−7.9	−34.0 to 18.3	0.553
Internal Medicine	5.3	−71.9 to 82.5	0.892
Faculty diversity, all faculty			
PWI, lowest tertile	Ref.		
PWI, middle tertile	−13.0	−43.9 to 17.8	0.405
PWI, highest tertile	−7.4	−38.0 to 23.2	0.633
PR	70.9	−7.2 to 148.9	0.075
Faculty diversity, women			
PWI, lowest tertile	Ref.		
PWI, middle tertile	−11.0	−43.8 to 21.7	0.506
PWI, highest tertile	−7.4	−39.9 to 25.1	0.653
PR	70.9	−12.0 to 153.8	0.093
Faculty diversity, men			
PWI, lowest tertile	Ref.		
PWI, middle tertile	−0.5	−34.4 to 33.3	0.975
PWI, highest tertile	1.8	−33.2 to 36.7	0.920
PR	78.3	−8.6 to 165.2	0.077
NIH funding, $M	−0.01	−0.08 to 0.07	0.816
USNWR top 10 ranking	−13.6	−49.7 to 22.6	0.458
Combined degree program	−12.2	−38.8 to 14.4	0.366
R1 university affiliation	11.8	−9.3 to 32.9	0.269
Peak COVID-19 infection rate per 100,000 people in county	−0.002	−0.005 to 0.001	0.154

Data source for number of faculty, faculty:student ratio, and faculty diversity: Association of American Medical Colleges Faculty Roster, December 31 snapshots as of December 31, 2021. CI, confidence interval; COVID-19, coronavirus disease 2019; NIH, National Institutes of Health; PR, Puerto Rico; PWI, predominantly White institution; R1, research intensive; Ref., reference; USNWR, US News and World Report.

[a]*Predicted change in median scholarly productivity growth (expressed as percentage change over number of publications in 2019).*

NIH funding.[5] As such, our results showing increasing medical school scientific output during the COVID-19 pandemic must be understood within the context of these preexisting inequalities in access to resources and opportunities for faculty participation in research.

Our findings indicate that 110 MD-granting institutions, the majority of such institutions, maintained sustained growth during the COVID-19 pandemic. This contrasts with many commentaries and scientists' self-reports of decreases in research productivity. The COVID-19 pandemic posed many challenges to scholarly work but provided further clinical and biomedical research and publication opportunities. With the curtailment of in-person work (excluding clinical duties) and spending increasing amounts of time at home under lockdown orders, scientists may have been able to focus more on manuscripts and grant writing. A qualitative study of NIH-funded researchers noted that for some scientists, laboratory closures and lockdowns provided more time for grant writing and manuscript publication and created

opportunities to pivot to more personally meaningful research topics.[35] During the COVID-19 pandemic we experienced the expansion of some funding sources to medical schools, including Coronavirus Aid, Relief, and Economic Security Act funding for COVID-19 relief and funding increases at the Department of Health and Human Services for COVID-19 response. COVID-19, however, was not the exclusive topic driving growth in scholarly activity during this time. For example, <5% of the NIH budget was allocated to COVID-19–related research in 2021.[36] Furthermore, an analysis of 10 high-impact medical and infectious disease journals found that in 2020, COVID-19–related publications accounted for 25% of research publications.[26] This was similar to our analysis of medical schools' experiencing the most rapid growth in publications, in which most of this growth was not driven by the number of articles produced about COVID-19.

Despite most medical schools' experiencing sustained growth throughout the pandemic, this growth was not equal. The most striking disparity is that all three HBCU medical schools were in the no growth category defined by our study. Existing studies have demonstrated the historical exclusion from the research enterprise and significant funding differences for HBCUs compared with PWIs.[37,38] The recognition of this disparity has led to attempts by several programs to affect funding distribution and research productivity (eg, Path to Excellence and Innovation [PEI]). The PEI program specifically targets HBCUs to increase NIH funding from <1% to ≥2. This program's pilot demonstrated some productivity increases for the groups selected in two partner HBCUs. PEI 2.0 launched in May 2021 and included all three HBCUs with medical schools, but any gains would not have been fully realized for this study. Significant continued investment and partnerships with HBCU medical schools are needed to address this inequity. Our findings also highlighted that a high level of diversity among female faculty at PWIs was associated with transient growth in publication productivity compared with sustained growth or no growth. The differential impact of the COVID-19 pandemic on female faculty academic productivity has been documented throughout the literature.[39] Early estimates indicated that the number of manuscripts submitted for publication was greater for men than women.[40] As the pandemic continued, institutional response and support were crucial to helping faculty, especially female faculty, with shifting caregiving, service, and other institutional demands. Changes in the ability to use research funds for childcare or other caregiver work have helped researchers dedicate more energy to their work.[41] Flexibility in work and institutional support has waned to some extent, however, as the pandemic continued. This change would make sustaining productivity difficult.[42]

Our study was limited by several aspects of the data sources and analytic approach. First, we focused on institution-level measures of scholarly productivity and thus could not address barriers to research encountered by individual investigators or disparities in research opportunities within institutions. Second, we focused on peer-reviewed publications as a measure of scholarly productivity, but not alternative metrics such as extramural grant funding (from all sources) or researchers' engagement with policymakers and the public. Third, we had limited data on institutional differences in support for faculty and trainee research, other than controlling for general measures of NIH funding and affiliation with R1 universities. Considering the direct impact of the pandemic on research productivity, we acknowledge that institutional research productivity also may have been affected by the specific characteristics of stay-at-home orders, including their timing, duration, and conditions.[43] Finally, considering the long period from conception to publication for many biomedical research studies,[5] we acknowledge that the full impact of the pandemic on institutional trajectories of scholarly productivity may not yet be visible and that disparities identified in our study may continue to widen in the coming years.

Despite these limitations, our study provides a timely update on the trajectory of biomedical research during the COVID-19 pandemic. At US MD-granting medical schools, we found that barriers to research associated with the pandemic did not preclude institutional-level growth in scholarly productivity for most institutions. Furthermore, this growth was not limited to publications on COVID-19, suggesting that pandemic-era increases in publications may be a continuation of recent trends and may augur further growth in scholarly output. A critical caveat to this finding, however, is that at a minority of medical schools (typically ones with lower scholarly output prepandemic), no growth or only transient growth in the number of publications occurred during the pandemic era to date. As such, trends in scholarly output during the COVID-19 pandemic threaten to widen the disparity among medical schools in available resources and expertise to pursue research activities. Although differences in publication rates across medical schools are multifactorial in origin, two important causes to consider are the disparity in research funding available to each school and the impact of structural racism that may hinder scholarly activity at HBCUs and minority-serving institutions, as well as among UIM faculty at PWIs. As such, further work is needed to identify scalable and sustainable strategies for enhancing equity in research opportunities across medical schools and among faculty within each medical school.

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