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RESEARCH ARTICLE

Impact of the COVID-19 pandemic on the productivity and career prospects of musculoskeletal researchers

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Abstract

Academic researchers faced a multitude of challenges posed by the COVID-19 pandemic, including widespread shelter-in-place orders, workplace closures, and cessation of in-person meetings and laboratory activities. The extent to which these challenges impacted musculoskeletal researchers, specifically, is unknown. We developed an anonymous web-based survey to determine the pandemic's impact on research productivity and career prospects among musculoskeletal research trainees and faculty. There were 116 musculoskeletal (MSK) researchers with varying demographic backgrounds who completed the survey. Of respondents, 48.3% ($n = 56$) believed that musculoskeletal funding opportunities decreased because of COVID-19, with faculty members more likely to hold this belief compared to nonfaculty researchers ($p = 0.008$). Amongst MSK researchers, 88.8% ($n = 103$) reported research activity was limited by COVID-19, and 92.2% ($n = 107$) of researchers reported their research was not able to be refocused on COVID-19-related topics, with basic science researchers less likely to be able to refocus their research compared to clinical researchers ($p = 0.030$). Additionally, 47.4% ($n = 55$) reported a decrease in manuscript submissions since the onset of the pandemic. Amongst 51 trainee researchers, 62.8% ($n = 32$) reported a decrease in job satisfaction directly attributable to the COVID-19 pandemic. In summary, study findings indicated that MSK researchers struggled to overcome challenges imposed by the pandemic, reporting declines in funding opportunities, research productivity, and manuscript submission. Trainee researchers experienced significant disruptions to critical research activities and worsening job satisfaction. Our findings motivate future efforts to support trainees in developing their careers and target the recovery of MSK research from the pandemic stall.

KEYWORDS

COVID-19, impact, musculoskeletal, pandemic, research

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1 | INTRODUCTION

The emergence of COVID-19 had profound impacts across the globe. As of September 2023, the pandemic has caused over 6.9 million deaths worldwide,¹ instigated massive economic decline,^{2,3} and overwhelmed healthcare systems in an unprecedented manner.⁴ Amongst widespread uncertainty, workplaces were forced to rapidly adapt to the new landscape shaped by COVID-19.^{5–8} In fact, healthcare workplaces were predominantly featured in this forced adaptation.^{9–12} Hospitals struggled to create isolated spaces for treating COVID-19 patients, establish policies and procedures regarding infection control, and manage widespread staffing shortages amid substantial deficits in critical supplies, such as ventilators and personal protective equipment (PPE).^{13–15} Within the field of healthcare itself, orthopedic surgery departments experienced high degrees of financial strain given the reliance of most practices on elective procedures to support overhead costs.^{16,17} Orthopedic surgery also has the additional burden of being one of the most expensive specialties in terms of medical malpractice costs.¹⁸ With most surgeons reporting >75% cancellation of their surgical workload per week,¹⁹ several orthopedic surgery departments were placed at significant financial risk. Decreased caseload posed additional implications for clinical trainees, who experienced dramatic declines in patient care exposure, participation in surgery, and faculty-led education.^{20,21} The stressors placed on orthopedic surgeons by the pandemic manifested in widespread mental health issues and job dissatisfaction.^{22–24}

Academic research was also affected by COVID-19. Many researchers were forced to end on-site lab work, animal studies, and recruitment of human subjects. Studies from early in the pandemic cite 30–40% declines in research time amongst bench science fields, such as biochemistry and the biological sciences, and a 24% reduction in clinical trial publications.²⁵ Many non-COVID related clinical trials were halted out of concerns for patient and staff safety, and subsequently experienced declines in patient recruitment, increased dropout rates, and redeployment of research staff.^{26,27} Communication was shifted online, with group and one-on-one meetings taking place virtually. Many researchers utilized this shift to write, and academia experienced a surge in manuscript and grant submissions, particularly in COVID-19 related subjects.^{28,29}

Given the changes in orthopedic surgery departments and academic research in general, it is reasonable to expect that musculoskeletal (MSK) researchers in general were similarly impacted by the COVID-19 pandemic. Specifically, new changes to clinical and laboratory practices likely affected MSK research productivity and trainee mentoring, impacting critical activities such as the ability to recruit human subjects, maintenance of animals for experiments, and complete in person lab work. MSK research is vital to advancing knowledge of debilitating conditions affecting millions of individuals worldwide, such as lower back pain, neck pain, and osteoarthritis.^{30–32} Declines in these research areas have downstream impacts on clinical perspectives and treatments, and thus potentially have long-term impacts on societal productivity should care regarding these conditions stop advancing.

In lieu of the aforementioned issues surrounding the COVID-19 pandemic, the following study was initiated by members of the

Orthopedic Research Society's (ORS) Spine Section to determine the nature and scope of the impact of the COVID-19 pandemic upon MSK researchers. Specifically, the goal was to examine how COVID-19 impacted the productivity and career prospects of MSK researchers as a function of demographics, career stage, laboratory type, and childcare responsibilities.

2 | METHODS

2.1 | Study design

An anonymous web-based survey consisting of 162 questions was developed to determine the impact of the COVID-19 pandemic on MSK researchers. This survey was based on a previous study¹⁹ and included fifteen questions focused on areas of research productivity, and eleven questions focused on the impact of COVID-19 on career prospects (Table 1). We previously reported on another aspect of this survey that addressed bullying, harassment, and discrimination in MSK research.³³ Research productivity was evaluated based on degree to which research was limited and consisted of the following: manuscript submissions, grant opportunities and submissions, and papers reviewed. The pandemic's impact on career prospects was assessed through perceptions of lost opportunities, fellowship contract changes, salary changes, and satisfaction levels.

The survey was approved by the Institutional Review Board of Duke University and distributed in English to approximately 4000 MSK researchers at universities and research societies in North America, Europe, and Asia via Qualtrics. The survey was circulated via e-mail to the ORS Spine Section membership, as well as national and international musculoskeletal research departments and institutions. These included Columbia University, Washington University in St. Louis, University of California at San Francisco, Rush University, Duke University, University of Lahore, Schroeder Arthritis Institute, Canadian Connective Tissue Society, University of Western Ontario Bone and Joint Institute, University of Pennsylvania, AO Foundation, University of Ulm, University of Nantes, BG Klinikum Bergmannstrost Halle, and Sheffield Hallam University. Responses were collected between July 30, 2021, and October 17, 2021.

All questions were assessed across age, gender, race, career stage, clinical/basic science research focus, and the presence of children in the home. Due to the sample size constraints, some variables were collapsed to allow for analysis. Specifically, age groups were merged to include 18–34, 35–54, and 55 and older respondents. Options for career stage included research staff, graduate student, post-doctoral researcher, early-career faculty (0–9 years since first academic appointment), mid-career faculty (10–19 years) and senior-career faculty (20 years or greater [20+]). Career stage was then grouped as “faculty” (early-career: 0–9 years since first appointment; mid-career: 10–19 years; senior-career: 20+ years) or “nonfaculty” (research staff, graduate students, and post-doctoral researchers). Trainee questions were directed at respondents who indicated they were research staff, graduate students, or

TABLE 1 Survey questions and responses.

Number	Condition	Question	Responses
Research productivity			
1		How has your research been impacted by the COVID-19 pandemic?	• Complete stop of research • Limited by >50% • Limited by <50% • Not impacted • Research has increased
2		Does your research require human subjects?	• Yes • No
3	If #2 = Yes	How has the COVID-19 pandemic impacted the recruitment of patients/subjects?	• Recruitment is more difficult • No impact on recruitment • Recruitment is easier
4		Does your research topic or expertise lend itself to refocus on COVID-19?	• Yes • No
5		Do you believe that research funding opportunities in your research area have decreased due to COVID-19?	• Yes • No
6	If academic career stage = early, mid, senior	How many manuscripts that you authored/co-authored have been submitted to a peer reviewed journal since the COVID-19 outbreak?	• 0 • 1-5 • 6-10 • 11-15 • 16-20 • 20+
7	If at academic career stage = graduate student, postdoctoral researcher, research staff member	How many manuscripts that you authored/co-authored have been submitted to a peer reviewed journal since the COVID-19 outbreak?	• 0 • 1-5 • 3-5 • 5+
8	If academic career stage = post-doctoral researcher, early, mid, senior	How many grant applications have you submitted since the COVID-19 outbreak?	• 0 • 1 • 2 • 3 • 4 • 5+
9		How has your productivity submitting peer reviewed journal articles been impacted by the COVID-19 pandemic?	• Decreased productivity • No change in productivity • Increased productivity
10	If academic career stage = postdoctoral researcher, early, mid, senior	How has your productivity submitting grants been impacted by the COVID-19 pandemic?	• Decreased productivity • No change in productivity • Increased productivity
11		How has the number of papers that you reviewed for peer-reviewed journals been impacted by the COVID-19 pandemic?	• Reviewed more • Reviewed less • Same amount as before • Not applicable
12		Does your research require animal testing?	• Yes • No
13	If does your research require animal testing = Yes	How many animals have you had to terminate due to the COVID-19 pandemic?	• 0-10 • 10-50 • 50-500 • >500

(Continues)

TABLE 1 (Continued)

Number	Condition	Question	Responses
14		Have you been reading more research literature during the COVID-19 pandemic?	• Yes • No
15		Has your access to literature decreased during the COVID-19 pandemic?	• Yes • No
Career prospects			
1		Has the COVID-19 pandemic negatively affected your career prospects?	• Yes • No • Not sure
2		Has your fellowship/contract been extended/shortened due to the COVID-19 pandemic?	• It has been extended • It has been shortened • It has stayed the same • It is uncertain at the moment • Other • Not applicable
3		Has COVID-19 affected your ability to perform the following work? (select all that apply)	• Conducting experiments • Data collection • Data analysis • Literature review • Writing • Discussing ideas with PI/colleagues • Sharing research findings • Writing fellowship or grant proposals • Other
4		In relation to the COVID-19 pandemic, my supervisor/PI has... (select all that apply)	• Provided clear expectations on how they will support me to manage any changes in my ability to work • Provided support and/or advice to help me continue my work remotely • Been in contact with me to check how I am managing • Made clear arrangement for our progress meetings to continue • Made arrangements to support me to stay in touch with other trainees at my university • Done all I believe they can/should to support me at this time
5		Do you believe you've lost a job or job offer because of COVID-19?	• Yes • No • Not sure • Other • Not applicable
6		How many years have you been in your current position?	• <1 year • 1-2 years • 2-5 years • 5-10 years • 10+ years
7		Have you received an increase or decrease in your annual (base) salary/compensation during the COVID-19 pandemic?	• Increase • Decrease • Neither/stayed the same • Prefer not to say • Not applicable
8	If #7 = Increase	What was the reason for your salary increase? (select all that apply)	• Annual review • Cost of living increase • Changes in job responsibility/title/promotion • Negotiation with manager/retention offer • Merit/good work • Completing qualification • Alignment with funders guidance/linked to external recommendations (e.g., NIH scale) • Moved to new job • Prefer not to say • Other

TABLE 1 (Continued)

Number	Condition	Question	Responses
9	If #7 = Decreased	What was the reason for your salary decrease? (select all that apply)	• Annual review • Budget/cutbacks (non-COVID-19 related) • Budget/cutbacks (COVID-19 related) • Changes in job responsibilities/title • Reduced working hours (non-COVID-19 related) • Reduced working hours (COVID-19 related) • Moved to a new job • Prefer not to say • Other
10		How satisfied are you in your current position?	• Satisfied • Somewhat satisfied • Not satisfied or dissatisfied
11		During the COVID-19 pandemic, would you say your level of satisfaction has	• Significantly worsened • Worsened a little • Stayed the same • Improved a little • Significantly improved

post-doctoral researchers. Degree responses were categorized as “terminal” (MD, PhD, MD/PhD) or “nonterminal” (BS, MS, other). Childcare responsibilities were categorized as “No Children” or “Children” (1, 2, 3, or 4 or more children in the home of any age).

2.2 | Statistical analyzes

All data was collected and encoded on a spreadsheet. Counts and percentages were reported for count data and rank-order questions. Where applicable, χ^2 tests were used to assess statistical significance across demographic groups. Fisher's exact tests were considered due to small sample size; however, were decided against given the prevalence of contingency tables containing more than two groups. Statistical analyzes were performed with R (RStudio, PBC). Multi-variate analysis was not feasible due to the sample size. The threshold for statistical significance was established at $p < 0.05$.

3 | RESULTS

3.1 | Respondent demographics

One hundred and twenty-six researchers completed the COVID-19 impact survey. Of those, 10 were excluded from the data analysis due to incomplete demographic information, resulting in a total of 116 complete responses for the analysis. Respondent demographic findings are summarized in (Table 2).

3.2 | Pandemic impact on funding opportunities and grant submissions

Perceptions regarding funding opportunities were assessed amongst all MSK researchers (Figure 1A, Table S1). Of MSK researchers ($n = 116$), 48.3% ($n = 56$) reported that funding opportunities decreased due to COVID-19, while 51.7% ($n = 60$) did not report that funding opportunities decreased due to COVID-19. Career stage was shown to be associated with the belief that funding opportunities decreased. Faculty were more likely to report that COVID-19 decreased funding opportunities compared to nonfaculty ($p = 0.008$). Productivity submitting grant applications was also assessed amongst post-doctoral researchers and faculty ($n = 84$) (Figure 1B, Table S2). Of these respondents 35.7% ($n = 30$) reported a decrease in the number of submitted grants, 52.4% ($n = 44$) reported no change, and 11.9% ($n = 10$) reported an increase in grant submissions.

3.3 | Pandemic impact on research activities and productivity

One hundred and sixteen individuals responded to questions regarding the impact of COVID-19 on research productivity

TABLE 2 Demographics of the survey respondents.

	Count (116)	% Total
Age		
18–24	3	2.6
25–34	36	31.0
35–44	40	34.5
45–54	23	19.8
55–64	11	9.5
65+	3	2.6
Gender		
Female	66	56.9
Male	50	43.1
Nonbinary/third gender	0	0.0
Prefer not to say	0	0.0
Other	0	0.0
Race		
Asian	20	17.2
Black or African American	1	0.9
Other	8	6.9
White	87	75.0
American Indian or Alaska Native	0	0.0
Native Hawaiian or Pacific Islander	0	0.0
Career stage		
Research staff member	12	10.3
Graduate student	20	17.2
Postdoctoral researcher	19	16.4
Early-career faculty	27	23.3
Mid-career faculty	24	20.7
Senior-career faculty	14	12.1
Degree		
BS	15	12.9
MS	11	9.5
MD	6	5.2
PhD	76	65.5
MD/PhD	5	4.3
Other professional degree	3	2.6
Children at home		
0	65	56.0
1	17	14.7
2	27	23.3
3	7	6.0
4+	0	0.0

TABLE 2 (Continued)

	Count (116)	% Total
Research field		
Nonclinical	83	71.6
Clinical	5	4.3
Both clinical and nonclinical	28	24.1
Region of residence		
Asia	2	1.7
Europe	29	25.0
North America	85	73.3
Primary research focus		
Ankle	2	1.7
Hip	3	2.6
Knee	7	6.0
Shoulder	1	0.9
Spine	40	34.5
Multiple regions	35	30.2
Other	28	24.1

(Figure 2A, Table S3). Overall, 88.8% ($n = 103$) of respondents reported research activity was limited in some capacity due to COVID-19. Of the remaining responses, 6.9% ($n = 8$) reported that their research was not impacted, and 4.3% ($n = 5$) reported their research increased. Career stage was shown to be associated with the overall impact of COVID-19 on research. Compared to nonfaculty, faculty members were more likely to have reported COVID-19 negatively impacted their research ($p = 0.007$).

Of the respondents, 92.2% ($n = 107$) reported that their research was not able to be refocused on COVID-19, with 7.8% ($n = 9$) reporting that their research was able to be refocused. Basic science researchers were more likely to report their research was not able to be refocused due to COVID-19 ($p = 0.03$) (Figure 2B, Table S4).

The impact of COVID-19 on the recruitment of human subjects was also assessed. Forty-one researchers responded to this question, with 90.2% ($n = 37$) reporting that human subject recruitment was more difficult due to the pandemic. Of the remaining responses, 9.8% ($n = 4$) reported no impact on human subject recruitment, and no researchers reported that human subject recruitment was easier. The pandemic had a similar impact on animal research. Of the 78 researchers that reported using animals in their work, 23% ($n = 18$) reported that they had to euthanize 10–50 animals because of the pandemic, 23% ($n = 18$) reported that they had to euthanize 50–500 animals, and 1% ($n = 1$) reported that they had to euthanize >500 animals.

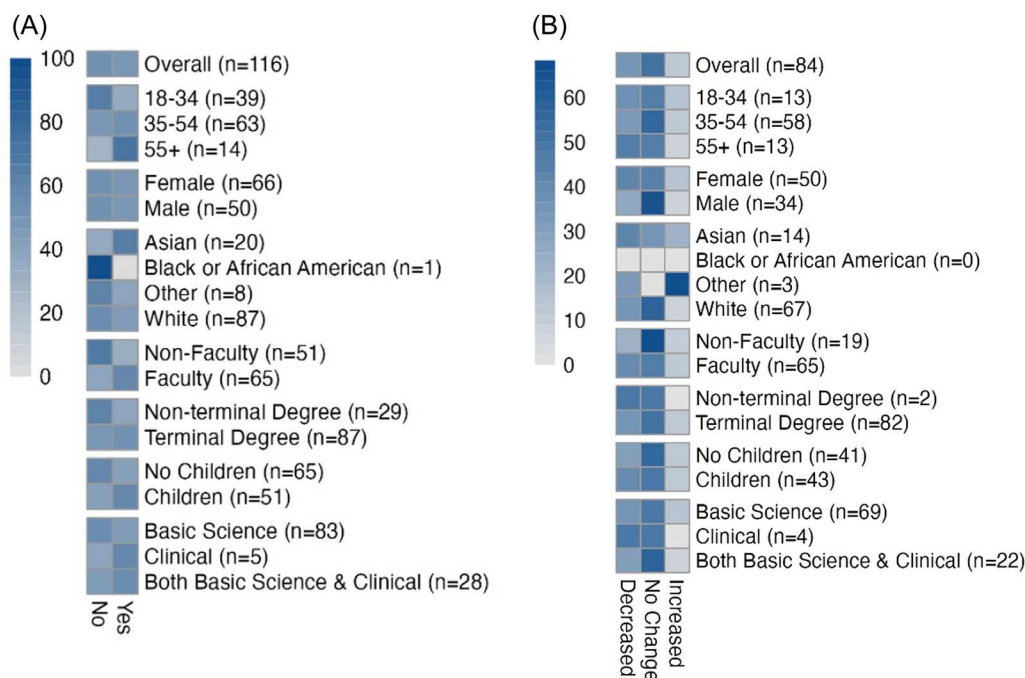


FIGURE 1 (A) Heatmap of the distribution of responses to "Do you believe that research funding opportunities in your research area have decreased due to COVID-19?" by age, gender, race, career stage, academic degree, children in the home, and laboratory type. (B) Heatmap of the distribution of responses to "How has your productivity submitting grants been impacted by COVID-19?" by age, gender, race, career stage, academic degree, children in the home, and laboratory type.

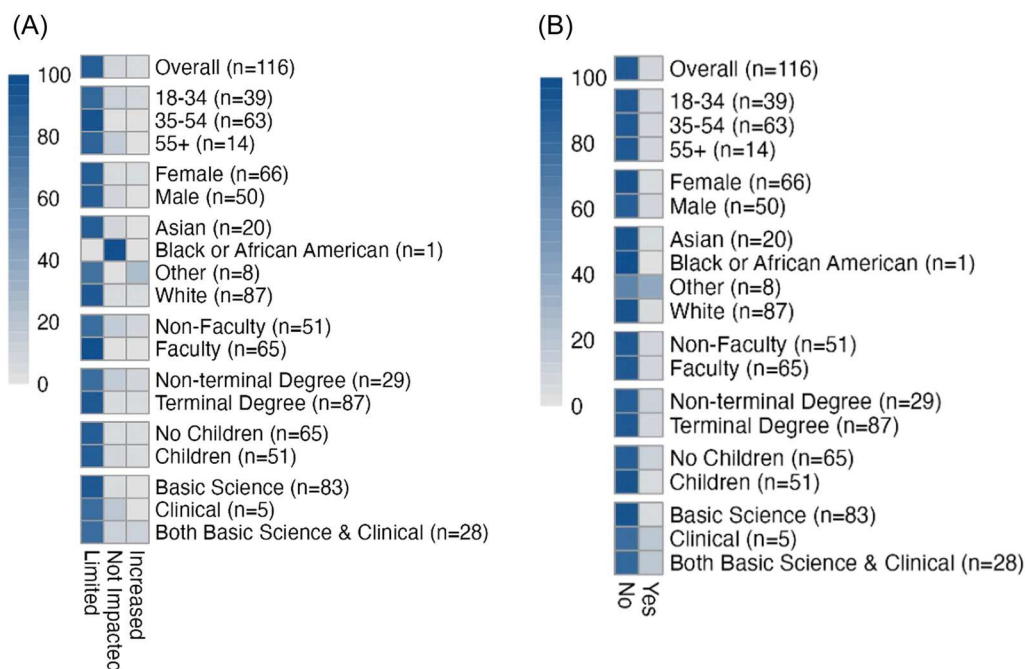


FIGURE 2 (A) Heatmap of the distribution of responses to "How has your research been impacted by the pandemic?" by age, gender, race, career stage, academic degree, children in the home, and laboratory type. (B) Heatmap of the distribution of responses to "Does your research topic or expertise lend itself to be refocused on COVID-19?" by age, gender, race, career stage, academic degree, children in the home, and laboratory type.

3.4 | Pandemic impact on manuscript submission and review

With regard to submitting manuscripts to peer-reviewed journals, 47.4% ($n = 55$) of respondents reported a decrease in submissions, 33.6% ($n = 39$) reported no change, and 19% ($n = 22$) reported an increase in submissions (Figure 3A, Table S5).

Researchers' ability to review articles was also assessed as a measure of research productivity (Figure 3B, Table S6). Eighty-five individuals responded to the question regarding the impact of COVID-19 on number of papers they were able to review, with 24.7% ($n = 21$) reporting a decrease in number of articles they reviewed, 44.7% ($n = 38$) reporting no change, and 30.6% ($n = 26$) reporting an increase in number of articles reviewed. The presence of children in the home (of any age) was found to be associated with the ability to serve as a reviewer of journal articles, however the results were mixed, with some reporting that the pandemic increased their productivity and others reporting that the pandemic decreased their productivity ($p = 0.044$). No other impact of children at home could be identified.

3.5 | Pandemic impact on trainees

Participants identifying as nonfaculty (research staff, graduate students, and post-doctoral researchers) received questions regarding the pandemic's effects on trainees. Fifty-one responded to the question regarding how COVID-19 negatively impacted career

prospects (Figure 4A, Table S7). Of these respondents, 39.2% ($n = 20$) reported that they did not believe COVID-19 pandemic negatively impacted their career prospects, 33.3% ($n = 17$) reported they were not sure of the COVID-19 pandemic's impact career prospects, and 27.5% ($n = 14$) believed that the COVID-19 pandemic resulted in a negative effect on career prospects. No differences amongst demographic groups were identified. Of the 51 trainee respondents, 62.8% ($n = 32$) reported worse satisfaction level with their position due to COVID-19, 25.5% ($n = 13$) reported their satisfaction level stayed the same, and 10% ($n = 6$) reported an improvement in satisfaction (Table S8). No differences were identified amongst demographic groups.

With regard to research activities, 46 trainees provided information on which types of research activities were negatively impacted by the pandemic (Figure 4B, Table S9). 82.6% ($n = 38$) reported a negative impact on conducting experiments, and 71.7% ($n = 33$) reported limitations in data collection. Discussing ideas with their principal investigator and colleagues (63%, $n = 29$) and sharing research findings (50%, $n = 23$) were the most reported activities negatively impacted by COVID-19. Writing (10.9%, $n = 5$) and literature review (8.7%, $n = 4$) were the two least impacted activities reported.

Forty-seven trainees responded to the questions regarding compensation changes during COVID-19. Of these respondents, 4.3% ($n = 2$) reported a decrease in salary, with one individual attributing this decrease to COVID-19-related budget cutbacks. 27.7% ($n = 13$) of respondents reported an increase in salary during COVID-19, with 53.8% ($n = 7$) attributing this increase to changes in job responsibilities and merit. 61.7% ($n = 29$) of respondents indicate

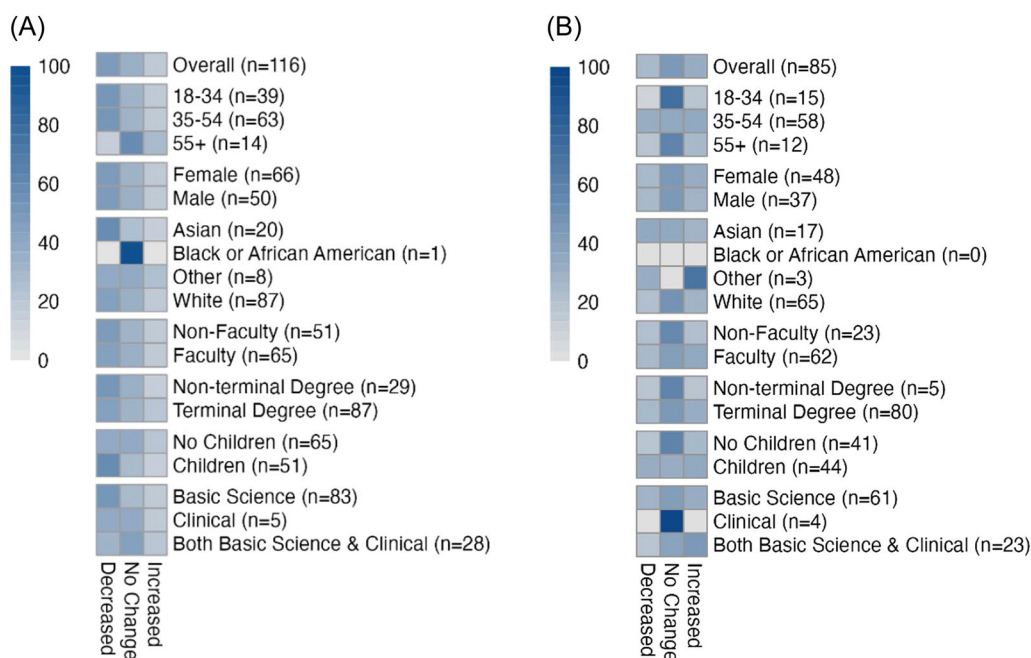


FIGURE 3 (A) Heatmap of the distribution of responses to "How has your productivity submitting peer reviewed journal articles been impacted by the COVID-19 pandemic?" by age, gender, race, career stage, academic degree, children in the home, and laboratory type. (B) Heatmap of the distribution of responses to "How has the number of papers you reviewed for peer-reviewed journals been impacted by the COVID-19 pandemic?" by age, gender, race, career stage, academic degree, children in the home, and laboratory type.

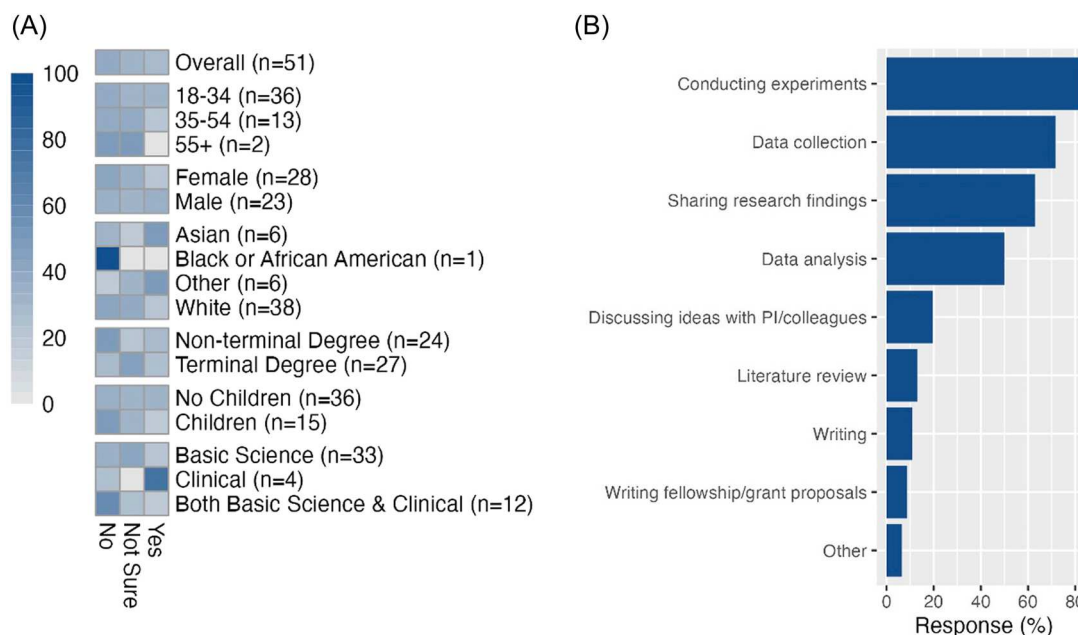


FIGURE 4 (A) Heatmap of the distribution of trainee responses to “Has the COVID-19 pandemic negatively affected your career prospects?” by age, gender, race, academic degree, children in the home, and laboratory type. (B) Research activities negatively impacted by COVID-19 as indicated by trainees.

their salary stayed the same, and 6.4% ($n = 3$) preferred not to say (Table S10).

4 | DISCUSSION

The onset of the pandemic fostered uncertainty and massive changes to researchers worldwide; however, the effects of those changes on research productivity and career prospects in the MSK research community are not well understood. This is the first study to our knowledge to assess the impact of COVID-19 specifically on MSK research productivity and career prospects. Among career stages, faculty reported a perception of decreased funding opportunities, more difficulty recruiting human subjects, and greater overall disruption to their research. Trainees were not protected from the pandemic and reported decreased satisfaction as well as significant disruptions to their research activities, which may have negatively impacted their career prospects. There were no differences found between genders. The results suggest that MSK researchers were not insulated from the negative impacts of the COVID-19 pandemic experienced by the greater research community.

Many MSK researchers expressed the belief that funding opportunities in MSK research have decreased due to COVID-19. Before the pandemic, virology research represented less than 2% of all biomedical research. Estimates following the pandemic onset suggest that COVID-19-related research studies comprised 10%–20% of biomedical research.³⁴ The National Institutes of Health/National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIH/NIAMS) launched several programs specifically aimed

at stimulating COVID-19 research.³⁵ The result of this is a perceived “crowding out” of non-pandemic related research topics that may reduce the confidence of researchers in applying for grants.³⁶ Our data suggest that the majority of MSK researchers were unable to redirect their research to a COVID-19 topic.

Because the primary effects of the COVID-19 are respiratory in nature, the focus of most studies regarding the pathogenesis of COVID-19 involved the respiratory and immune systems. It was not until recently that researchers began to examine the impact of COVID-19 on the MSK system, specifically in the context of long-COVID,^{37–39} a phenomenon that presented itself well into the course of the pandemic. Lifestyle changes caused by the pandemic are also thought to be associated with a post-pandemic increase in back pain,⁴⁰ indicating potential future research opportunities for MSK researchers. We propose that MSK researchers can recover from the pandemic-related research decline by focusing grant-writing efforts on the long-term impacts of COVID-19 on the MSK system.

Additionally, MSK researchers were not isolated from the challenges faced by other academics in maintaining human and animal research cohorts. The majority of MSK researchers reported difficulty recruiting human subjects, as many departments prohibited research with human participants altogether, and some even shut down their basic science laboratories.^{41–43} MSK researchers performing animal studies were also required to euthanize many of their animals, consistent with reports of mass euthanasia of research animal colonies in other fields.⁴⁴ Our data suggest that MSK researchers performing studies using human participants or animals struggled to maintain research cohorts in face of challenges imposed by the pandemic.

Most trainees reported decreased satisfaction directly due to COVID-19. Many trainees reported disruption in crucial research areas, such as conducting experiments and data collection, nearly one-third of respondents indicated that they had lost a job or job offer because of COVID-19, and many trainees indicated the pandemic negatively affected their career prospects. Considering the perception of lost job opportunities in context of trainees' belief that the pandemic negatively impacted career prospects suggests uncertainty about future career prospects within a highly competitive field. Trainees also reported bullying, harassment, and discriminatory behaviors (reported in the prior publication from the same survey^{33,45,46}), which may be another factor contributing to the overall dissatisfaction reflected in our data. Additionally, over sixty-five percent of trainees reported their salary either stayed the same or decreased. This may be attributed to pandemic-based factors, such as the freezing of annual merit-based salary increases.⁴⁷⁻⁴⁹ Uncertainty regarding job prospects, training, and ongoing experiments creates an unstable environment in which trainees are under-supported and highlights a potential area for further work.

4.1 | Strengths and limitations

This study is the first of its kind to address the impact of COVID-19 on research productivity and career prospect amongst MSK researchers. However, as with any survey-based study, limitations inherently exist. The survey was distributed to over 4,000 researchers with 116 responses, yielding a survey response rate of approximately 4%. As a result of poor response rate and limited sample size, the findings of this paper may be over- or under-stated. Additionally, our survey was distributed in 2021 when globally there was stratified progress regarding return to work. Institutional policies varied geographically, and thus it is unknown if some researchers had returned to laboratories during this time and may have experienced a return to normalcy while others were still quarantined in a "work-from-home" environment. While this may complicate an attempt to quantify direct impacts of the pandemic on research, it is useful in assessing the pulse of research at the time. Additional studies assessing the current state of MSK research would be useful to compare as a "post-pandemic" measure further assessing the long-term impact of the pandemic on MSK research. Finally, it was not appropriate to perform multivariate analysis due to limited sample size; however, descriptive statistics coupled with univariate analysis identified potential risk factors that could be the subject of further validation.

5 | CONCLUSIONS

The widespread shutdowns and constantly evolving landscape of the COVID-19 pandemic posed unprecedented challenges to MSK researchers. Our study, the first of its kind to our knowledge, noted that MSK researchers reported an overall decrease in research productivity, with decreased funding opportunities and difficulty

recruiting human subjects and maintaining animal colonies. This period of uncertainty fostered an unstable environment, particularly for trainees, who experienced the cessation of major research activities and decreased job satisfaction. Coupled with evidence of bullying, harassment, and discrimination,³³ these factors contributed to a negative outlook regarding trainee job prospects and indicate that more support is needed in developing trainee researchers. Given the negative impacts of COVID-19 on research productivity, future attention is needed on how best to facilitate recovery of MSK research; for example, through research on the links between long COVID and MSK disease, and the nature of potential long-term impacts on MSK research and the MSK research workforce. This study also highlights several factors for institutions and policy-makers to consider when developing frameworks to support MSK researchers through future adverse events so that critical research in this domain continues.

CONFLICT OF INTEREST STATEMENT

The authors have no financial or competing interests to declare in relation to this work.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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