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Impacts of COVID-19 on Research Productivity: Disruptions to the Pipeline for Early Career Researchers

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Abstract: The COVID-19 pandemic resulted in productivity losses, particularly for early career researchers (ECRs) who do not have the same track record as their non-ECR colleagues. Therefore, the purpose of the current study was to examine differences in time allocation and research productivity outcomes between ECRs and non-ECRs at a Carnegie Classification R1 University in the United States. We quantitatively and qualitatively examined differences in time allocation (i.e., research, teaching) and research productivity outcomes (e.g., peer-reviewed publications), as well as pandemic-related challenges, between ECRs and non-ECRs over three time periods: pre-pandemic, year one of the pandemic, and the first eight months of year two of the pandemic. Compared to non-ECRs, ECRs reported significantly more time spent on research, less time on teaching, fewer peer-reviewed publications, and fewer funding proposal submissions during the pandemic. Qualitative data revealed three broad categories of pandemic-related challenges: tangible (e.g., research delays), intangible (e.g., mental health), and long-term impacts on career trajectory (e.g., delayed promotion). The implications for future research and for universities looking to mitigate adverse impacts of the pandemic for ECRs are discussed.

Keywords: COVID-19; productivity; early career researchers; career trajectory

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1. Introduction

The COVID-19 pandemic has dramatically altered the academic landscape in the United States (U.S.). The initial impact of the pandemic on research productivity[1] (e.g., reduced time devoted to research, fewer peer-reviewed publications) has been well-documented (Harrop et al. 2021; Chim et al. 2023; Krukowski et al. 2021; Myers et al. 2020; Viglione 2020). The research shows disproportionate impacts on researchers early in their careers, herein referred to as early career researchers (ECRs)[2] (Chim et al. 2023; Krukowski et al. 2021; Myers et al. 2020; Rupnow et al. 2020; Sotto-Santiago et al. 2021; Viglione 2020). Non-ECRs are typically in the mid-to-late stages of their career and have an established track record of funding and research success. Although non-ECRs faced similar pandemic-related challenges (e.g., university office closures, shift to remote teaching instruction), ECRs have less job security and a shorter track record, putting them in a more vulnerable position in their career trajectories (Iding et al. 2023; Johnson and Weivoda 2021; Sotto-Santiago et al. 2021; Spagnolo et al. 2020). While some research suggests that productivity rebounded quickly once universities resumed normal operations, there is limited research on the continued impacts of the pandemic, particularly among ECRs (Chim et al. 2023; Iding et al. 2023; Lee et al. 2023; Mayowski et al. 2023). Therefore, the present study adds to this research by examining differences in time allocation (e.g., to research, teaching) and research productivity outcomes (e.g., peer-reviewed publications) between ECRs and non-ECRs across three time periods (i.e., the year before and the first two years of the pandemic). We also qualitatively explored the most common pandemic-related challenges reported by both ECRs and non-ECRs.

1.1. Academic Transitions

Prior to the COVID-19 pandemic, the National Research Council (2005) reported that ECRs in the U.S. often face lower success rates (e.g., number of publications and citations, external funding awards, student evaluation scores) compared to non-ECRs (Archer 2008; Bostock 2014). The "early career phase" is marked by a series of transitions, which may explain the differences in productivity between ECRs and non-ECRs. For instance, ECRs often begin their careers at new institutions. This requires a period of adjustment not only to a new workplace environment (e.g., department dynamics, colleagues, geographic location) but to new tasks and performance expectations set by the university (e.g., setting up their research lab, preparing courses) (Laudel and Gläser 2008). Furthermore, the early career phase is marked by a transition from dependent to independent research (Laudel and Gläser 2008). ECRs build on their research conducted as graduate students and postdoctoral scholars to gradually expand and establish their own research base. This often involves ECRs establishing connections with non-ECRs to collaborate on projects and preparing future funding proposals (Bridle et al. 2013; Laudel and Gläser 2008).

However, ECRs must also balance their research with competing expectations, such as teaching and service (Meyer and Evans 2005). During the early career phase, ECRs may struggle to simultaneously prepare and teach courses and mentor undergraduate and graduate students while executing their current research projects and attempting to expand their independent research (e.g., submit proposals for external funding). The raising expectations for grant funding applications can also pose additional challenges for ECRs (National Research Council 2005). Some studies highlight the systemic disadvantages of ECRs in obtaining external funding as they do not have the same track record as non-ECRs. This research also suggests that ECRs are at a disadvantage based on their working conditions, including time constraints resulting from teaching and administrative tasks (Bazeley 1999, 2003; Bazeley et al. 1996).

1.2. Impact of COVID-19 on Early Career Researchers

In the initial stages of the pandemic, recommendations from the World Health Organization and Centers for Disease Control and Prevention shifted university offices nationwide from in-person to online. Not only did this hinder the ability of researchers to conduct their work, but it also increased teaching demands, largely due to the shift to remote instruction (Krukowski et al. 2021; Myers et al. 2020; Rupnow et al. 2020). As a result, research productivity decreased during this period, particularly for ECRs, women, and those with caregiving responsibilities (Andersen et al. 2020; Chim et al. 2023; Harrop et al. 2021; Krukowski et al. 2021; Mayowski et al. 2023; Myers et al. 2020; Rupnow et al. 2020; Viglione 2020).

Although non-ECRs faced similar challenges, ECRs do not have the same track record as their non-ECR colleagues in terms of peer-reviewed publications, teaching evaluations, and funded proposals. Therefore, the conditions imposed by the pandemic differentially affected ECRs, potentially limiting their ability to advance in or retain their position. For instance, Chim et al. (2023) found that ECRs were significantly more likely to report delays in their research than mid- and advanced career researchers. Another study by Harrop et al. (2021) found that 85% of ECRs reported a reduction in their research productivity (Chim et al. 2023; Mayowski et al. 2023). Almost all ECRs in their study reported negative impacts to their research, largely due to difficulties in participant recruitment, home-life needs, and mental health (Chim et al. 2023; Harrop et al. 2021). Compared to their non-ECR colleagues, ECRs also had fewer publications and were less likely to pursue new lines of research early in the pandemic (Andersen et al. 2020; Chim et al. 2023; Viglione 2020).

Furthermore, pandemic-imposed travel restrictions and limited face-to-face interactions hindered collaboration and networking opportunities that are critical for ECRs professional success (Chim et al. 2023; Tchieu et al. 2020). The inability to attend conferences and obtain feedback on research can stunt research innovation, creativity, and growth of ECRs. ECRs also reported adverse impacts from the lack of training opportunities and

field experience during the pandemic (Chim et al. 2023). In addition, although both ECRs and non-ECRs were faced with reduced funding opportunities (e.g., grant funding cycle cancellations, reallocating funds), limited access to funding hindered the ability of ECRs to obtain funding to sustain their research efforts and facilitate job security (Chim et al. 2023; Iding et al. 2023; Myers 2021). Taken together, these pandemic-related challenges may not only hinder ECRs' career advancement but possibly derail their future career trajectory (Alper 1993; Gregor et al. 2023; Kabat-Farr and Cortina 2014; Raabe et al. 2019).

Little research has directly compared ECRs and non-ECRs over the course of the pandemic (Andersen et al. 2020; Chim et al. 2023; Harrop et al. 2021; Krukowski et al. 2021; Myers et al. 2020; Viglione 2020). Much of the literature on the impact of COVID-19 on ECRs has been published as commentaries and editorials, as opposed to participant-driven research (Iding et al. 2023; Johnson and Weivoda 2021; López-Vergès et al. 2021; Kent et al. 2020; Termini and Traver 2020). The little research that does exist focuses primarily on the immediate aftermath of the pandemic, after physical facilities closed in 2020 (Andersen et al. 2020; Chim et al. 2023; Harrop et al. 2021; Krukowski et al. 2021; Mayowski et al. 2023; Myers et al. 2020; Viglione 2020). Therefore, capturing the continued impact of the pandemic on ECRs, compared to non-ECRs, is crucial for universities looking to mitigate the long-term disparities experienced by ECRs and support their career success.

2. Conceptual Framework

The series of transitions facing ECRs underscore the lower levels of research productivity compared to non-ECRs prior to the COVID-19 pandemic. These challenges were exacerbated by the pandemic and have long-term career implications (Krukowski et al. 2021; Chim et al. 2023; Rupnow et al. 2020; Sotto-Santiago et al. 2021). We draw from two frameworks to help explain the impact of the pandemic on ECRs: (1) the pipeline framework (Alper 1993; Cimpian et al. 2020) and (2) Social Cognitive Career Theory (Gregor et al. 2023; Lent et al. 1994).

2.1. The Pipeline Framework

The effort to recruit and retain research faculty, particularly women and people of color, can begin in high school and college and continue through graduate school into their early careers (Alper 1993; Cimpian et al. 2020). Researchers have referred to this process as a 'pipeline,' as there are many timepoints where interested and qualified students and faculty "leak-out" or leave the field (Alper 1993; Berryman 1983; Gregor et al. 2023; Skrentny and Lewis 2022). To date, a host of research has documented internal (e.g., lack of motivation) and external (e.g., lack of support, gender harassment) factors that result in this leaky pipeline (Cimpian et al. 2020; Gregor et al. 2023; Kabat-Farr and Cortina 2014; Raabe et al. 2019).

Among ECRs, the research shows that job insecurity serves as a commonly reported "leak" in this pipeline, compromising ECRs' long-term career trajectory (Ferri et al. 2016). Job insecurity not only affects ECRs' current work performance but their ability to meet research goals and their level of job satisfaction. Ferri et al. (2016) also identified the lack of professional or departmental fit as a "leak" or obstacle to continuing their career path. Even though ECRs frequently acknowledged the positive climate of their department, many reported low levels of collaboration with their colleagues (Ferri et al. 2016). Furthermore, ECRs noted the lack of professional recognition from their department (both of their work and of their students) as another barrier to their career development (Ferri et al. 2016). Therefore, the limited collaboration and networking opportunities, compounded with lack of funding to facilitate job security, resulting from the COVID-19 pandemic may create additional places for ECRs to "leak-out" or leave the pipeline altogether (Chim et al. 2023; Iding et al. 2023; Myers 2021; Tchieu et al. 2020).

In addition, research on ECRs who "leaked-out" of the pipeline documented the pace of work and care responsibilities as reasons for leaving (Ferri et al. 2016). ECRs frequently reported that the pace of work and set expectations (e.g., number of publica-

tions, conferences to attend, teaching, proposal writing) were excessively demanding. The high demand of work responsibilities also left limited time for ECRs' home-life, particularly caregiving responsibilities. Many ECRs reported needing to prioritize their families during this stage of their lives, and the inability to reconcile work expectations with home-life responsibilities served as another obstacle to continuing with their research career (Ferri et al. 2016). The COVID-19 pandemic posed additional challenges related to work–life balance, particularly for young researchers with children (Collins et al. 2021; Cui et al. 2022; Dang and Nguyen 2021; Frank et al. 2021; Moschella-Smith and Potter 2024; Power 2020). Mandatory daycare and school closures resulted in an increased need for childcare and remote schooling. The additional caregiving responsibilities during COVID-19 not only reduced productivity for many researchers but may push ECRs to "leak-out" or leave the pipeline (Chim et al. 2023; Collins et al. 2021; Cui et al. 2022; Dang and Nguyen 2021; Harrop et al. 2021; Moschella-Smith and Potter 2024). Further support for the leaky pipeline can be found through social cognitive career theory.

2.2. Social Cognitive Career Theory

Social cognitive career theory (SCCT) identifies internal and external factors that facilitate or hinder one's career progression and examines how external factors can positively or negatively affect internal factors (Gregor et al. 2023; Lent 2013; Lent and Brown 2019; Lent et al. 1994). External or contextual factors include the working environment, such as the organizational structure, expectations, and relationship dynamics, whereas internal factors include one's assessment of their ability to perform, such as self-efficacy, and their goals for their career outcomes (Lent et al. 1994). A study by Gregor et al. (2023) found that external supports (e.g., presence of mentors, institutional resources) can facilitate the obtainment of tenure, while external obstacles (e.g., lack of mentors, limited research opportunities) can impede career success. External obstacles such as these may also be reflective of the "sticky floor", where women and minority researchers receive less institutional resources than their colleagues (Brown et al. 2020; Shah et al. 2022). This lack of investment and support can further hinder ECR career advancement and retention.

Furthermore, Fleming et al. (2016) identified the importance of organizational context and individual characteristics among new faculty. Their findings highlight the positive impact of departments with cultures of engagement and support on new faculty. In contrast, departments that did not offer a supportive environment were challenging and often counterproductive for new faculty (Fleming et al. 2016). While the literature on the pipeline and SCCT has identified barriers to career success, the recent research suggests that the COVID-19 pandemic exacerbated these challenges, particularly among ECRs (Chim et al. 2023; Krukowski et al. 2021; Myers et al. 2020; Viglione 2020). Indeed, the external obstacles posed by the pandemic, such as the limited institutional resources and opportunities for mentorship and collaboration, may result in negative career outcomes that result in ECRs leaving the pipeline altogether (Castellanos 2018; Chim et al. 2023; Gregor et al. 2023; Myers 2021; Tchieu et al. 2020).

2.3. The Current Study

The current study examined differences between ECRs and non-ECRs in self-reported time allocation (i.e., to research, teaching) and research productivity outcomes (i.e., peer-reviewed publications, funding proposal submissions) across three time periods (i.e., pre-pandemic and the first two years of the pandemic). We also qualitatively explored pandemic-related challenges for both ECRs and non-ECRs.

Aim 1: *Examine differences in time allocation and research productivity outcomes between ECRs and non-ECRs: pre-pandemic, year one, and year two of the pandemic.*

Aim 2: *Describe pandemic-related professional and personal challenges for ECRs and non-ECRs.*

3. Materials and Methods

3.1. Procedures

The research was conducted at a Carnegie Classification R1 University in the U.S. In fall 2021, the University's Office of the Senior Vice Provost for Research invited all faculty and staff engaged in research (N = 844) to participate in a study on the impacts of the COVID-19 pandemic. Faculty and staff were invited via email, which included the link to an online survey (administered via Qualtrics) about pandemic-related challenges and changes in research productivity outcomes. Upon survey completion, the participants were invited to participate in a 15-min follow-up interview about the impact of the pandemic on their career trajectory. Interviews were conducted via phone within one week of survey completion. Participants self-selected into both the survey and interview and gave their informed consent prior to participation in research activities. All the research was conducted in accordance with the researchers' university Institutional Review Board (IRB-FY2021-90).

3.2. Participants

The survey data were collected from 227 faculty and staff engaged in research (response rate of 26.9%). Of the 227 participants who completed the survey, 19.4% (N = 44) volunteered to complete a 15-min follow-up interview. Table 1 presents demographic characteristics of the ECR and non-ECR survey and interview participants. For the purposes of this study, we defined ECRs as researchers at the postdoctoral level or faculty and staff within the first five years of their position after graduation (e.g., tenure-track faculty, non-tenure track research faculty, research scientist). Our sample included a higher percentage of women (59.9%) compared to non-respondents (52.0% of faculty and staff who were invited but did not participate). The university position was similar between our sample and non-respondents (51.3% tenure-track faculty compared to 52.0% of non-respondents, 40.3% non-tenure track faculty compared to 43.0% of non-respondents, and 8.2% postdoctoral researchers compared to 5.0% of non-respondents).

Table 1. Demographic information by career status.

Survey Participants (N = 227)			
Characteristic	**Early Career Researchers (n = 75)**	**Non-Early Career Researchers (n = 156)**	**Total (n = 227)**
	n (%)	n (%)	n (%)
Gender Identity			
Woman	48 (64.0)	91 (58.0)	139 (59.9)
Man	23 (30.7)	62 (39.7)	85 (36.6)
Sexual Orientation			
Heterosexual	56 (74.7)	137 (87.3)	193 (83.2)
LGBQ+	14 (18.7)	10 (6.4)	24 (10.3)
Age			
25–34	37 (48.7)	2 (1.3)	39 (16.8)
35–44	37 (48.7)	36 (22.9)	73 (31.5)
45–64	0 (0)	100 (63.7)	100 (43.1)
65+	0 (0)	18 (11.5)	18 (7.8)
Race			
White	54 (72.0)	142 (90.4)	196 (84.5)
Participants of Color	18 (24.0)	11 (7.0)	29 (12.5)
Children			
Children Living at Home	32 (42.7)	84 (53.5)	116 (50.0)
Children Not Living at Home or No Children	43 (57.3)	71 (45.2)	114 (49.1)
Academic Position			
Postdoctoral Scholar	19 (25.3)	0 (0)	19 (8.2)
Non-tenure Track Faculty	24 (32)	69 (44.2)	93 (40.3)
Tenure-track Faculty	32 (42.7)	87 (55.4)	119 (51.3)
Department			
Social Sciences	28 (54.8)	75 (54.7)	109 (54.8)
Natural Sciences	34 (45.2)	62 (45.3)	90 (45.2)

Table 1. *Cont.*

Interview Participants (N = 44)			
Characteristic	**Early Career Researchers (n = 17)**	**Non-Early Career Researchers (n = 27)**	**Total (n = 44)**
	n (%)	n (%)	n (%)
Gender Identity			
Woman	12 (75.0)	16 (59.3)	28 (63.6)
Man	4 (25.0)	11 (40.7)	15 (34.1)
Sexual Orientation			
Heterosexual	14 (82.4)	24 (88.9)	38 (86.4)
LGBQ+	3 (17.6)	3 (11.1)	6 (13.6)
Age			
25–34	8 (47.1)	0 (0.0)	8 (18.2)
35–44	9 (52.9)	10 (37.0)	19 (43.2)
45–64	0 (0.0)	6 (22.2)	6 (13.6)
65+	0 (0.0)	11 (40.7)	11 (25.0)
Race			
White	16 (94.1)	27 (100.0)	43 (97.7)
Participants of Color	1 (5.9)	0 (0.0)	1 (0.3)
Children			
Children Living at Home	10 (58.8)	17 (63.0)	27 (61.4)
Children Not Living at Home or No Children	7 (41.2)	10 (37.0)	17 (28.6)
Academic Position			
Postdoctoral Scholar	5 (29.4)	0 (0.0)	5 (11.4)
Non-tenure Track Faculty	5 (29.4)	10 (37.0)	15 (34.1)
Tenure-track Faculty	7 (41.2)	17 (63.0)	24 (54.5)
Department			
Social Sciences	7 (41.2)	15 (55.6)	22 (50.0)
Natural Sciences	10 (58.8)	12 (44.4)	22 (50.0)

3.3. Measures

3.3.1. Survey Questions

The online survey included four parts. (1) Participants first provided demographic information (e.g., gender, race) and their university position (e.g., research faculty, tenure-track faculty). (2) Next, participants self-reported the percentage of time they spent on work-related activities (i.e., research and teaching) and the number of research outcomes produced (i.e., peer-reviewed publications and funding proposals submitted). These set of questions were asked for three time periods: pre-pandemic (March 2019–February 2020), year one of the pandemic (March 2020–February 2021), and the first eight months of year two of the pandemic (March 2021–October 2021). (3) Participants with children were then asked about childcare responsibilities during the pandemic. (4) Lastly, participants completed two open-ended questions about pandemic-related challenges (i.e., Describe the main barriers to your work productivity during the COVID-19 pandemic and describe the positive and negative impacts of COVID-19 on your career well-being and trajectory). However, only two-thirds of participants (n = 157, 69.2%) completed these open-ended survey questions.

3.3.2. Interview Questions

The participants' survey responses were connected to and used to guide the follow-up interviews. The interview questions focused on the barriers participants faced regarding the COVID-19 pandemic, as well as real or projected impacts on their career trajectory (e.g., Could you tell me a little bit more about how [challenges indicated in survey responses] have impacted your research and work performance; what could have been done at the university- or department-level to mitigate [challenges indicated in survey responses]?). Subsequent clarification questions were asked.

3.4. Data Analysis Plan

The quantitative data were analyzed using SPSS Statistics (Version 28). To examine differences in time allocation and research productivity outcomes from pre-pandemic to year two of the pandemic (Aim 1), we conducted repeated measures analyses of variance (ANOVAs) with a Greenhouse–Geisser correction, controlling for discipline type (i.e., natural vs. social science). The interactions between period (i.e., pre-pandemic, year one, and year two) and career status (i.e., ECR vs. non-ECR) were tested. To further examine differences between ECRs and non-ECRs, we conducted independent t-tests for time allocation and research productivity outcomes at each period.

Only 157 participants (ECRs = 49; non-ECRs = 108) answered the open-ended survey questions or participated in interviews about the impact of the pandemic on their careers. The qualitative data were entered into Atlas.ti and analyzed through thematic analysis (Aim 2; Braun and Clarke 2006; Charmaz 2005). In the first step of the thematic analysis, two authors read through the transcripts and met to create an initial coding scheme. Next, both authors coded one-third of the transcripts and revised the coding scheme. The authors had regular meetings to discuss the coding scheme and identify overarching themes within the data. In the third step, two authors double-coded half of all open-ended survey responses and 15% of all transcripts to ensure the reliability of the coding scheme (94.0% agreement). Any discrepancies were discussed until a resolution was reached. The authors then coded the remaining open-ended survey responses and transcripts. Dichotomous variables were created for each code that emerged (0 = code not present, 1 = code present). We then performed chi-square tests of independence to explore the relationship between career status (i.e., ECR vs. non-ECR) and each pandemic-related challenge.

4. Results

4.1. Time Allocation and Research Productivity Outcomes

Repeated measures ANOVAs were conducted to examine changes in time allocation and research productivity outcomes across three periods: pre-pandemic, year one, and year two of the pandemic, controlling for discipline type (see Table 2 for mean scores). The results revealed no main effects for time spent on research or teaching. There was, however, a significant interaction for career status on time spent on teaching, $F(1.76, 242.83) = 3.89$, $p < 0.05$, indicating that ECRs reported a greater increase in time spent on teaching compared to non-ECRs between pre-pandemic and year one of the pandemic. There was no significant interaction for career status and time spent on research.

Table 2. Time allocation and productivity outcomes by career status.

Time Allocation	Early Career Researchers (n = 75)	Non-Early Career Researchers (n = 156)	*t*
	M (SE)	M (SE)	
Research			
Pre-pandemic	54.1 (3.70)	37.7 (2.55)	−3.52 **
Year 1	48.5 (3.99)	31.0 (2.75)	−3.66 ***
Year 2	51.7 (3.91)	34.4 (2.69)	−3.62 ***
Teaching			
Pre-pandemic	22.8 (3.35)	34.8 (2.18)	2.84 **
Year 1	32.8 (3.85)	40.5 (2.51)	1.53
Year 2	28.0 (3.58)	35.6 (2.33)	1.67
Productivity Outcomes			
Peer-review Publications			
Pre-pandemic	2.0 (0.45)	3.3 (0.30)	3.07 **
Year 1	1.6 (0.39)	2.4 (0.26)	2.17 *
Year 2	1.5 (0.39)	2.0 (0.26)	1.31
Funding Proposal Submissions			
Pre-pandemic	0.8 (0.36)	1.9 (0.25)	3.16 **
Year 1	1.1 (0.29)	1.5 (0.19)	1.33
Year 2	0.6 (0.22)	1.1 (0.15)	2.26 *

$p < 0.05$ *, $p < 0.01$ **, $p < 0.001$ ***.

The results of repeated measures ANOVAs also revealed a significant main effect on the number of peer-reviewed publications, $F(1.87, 241.21) = 4.23$, $p < 0.05$, and funding proposals submitted, $F(1.74, 212.16) = 8.82$, $p < 0.001$. Both ECRs and non-ECRs reported decreases in the number of peer-reviewed publications from pre-pandemic to year two of the pandemic. Although non-ECRs reported decreases in the number of funding proposals submitted across all three periods, ECRs reported a slight increase between pre-pandemic and year one but then decreases in year two of the pandemic. There was a significant interaction for career status on the number of funding proposals submitted, $F(1.74, 4.58) = 2.87$, $p < 0.10$, indicating that non-ECRs reported a greater reduction in the number of funding proposal submitted compared to ECRs between pre-pandemic and year one of the pandemic. There was no significant interaction for career status and peer-reviewed publications.

In addition, independent *t*-tests were conducted to examine differences between ECRs and non-ECRs at each period: pre-pandemic, year one, and year two of the pandemic (see Table 2). ECRs reported significantly more time spent on research than non-ECRs in all three time periods. Compared to non-ECRs, ECRs spent significantly less time on teaching pre-pandemic. ECRs also reported significantly fewer peer-reviewed publications than non-ECRs pre-pandemic and year one of the pandemic. Lastly, ECRs reported significantly fewer funding proposal submissions compared to non-ECRs pre-pandemic and year two of the pandemic.

4.2. Pandemic-Related Challenges

The qualitative data revealed three broad categories of pandemic-related challenges: (1) tangible challenges, (2) intangible challenges, and (3) long-term impacts on career trajectory. These categories are further broken down into subthemes.

4.2.1. Tangible Challenges

Five overarching themes emerged that were categorized as "tangible challenges": (1) research delays, (2) limited collaboration and networking opportunities, (3) teaching and student demands, (4) restricted access to research sites and populations, and (5) funding interruptions. The tangible challenges described concrete barriers to research productivity. Over 85% of participants (n = 137, 87.3%) reported at least one tangible challenge related to the pandemic.

Research Delays. More than half (n = 99, 63.1%) of participants reported that a research project was delayed or cancelled due to the pandemic, including delays in data collection, extending research timelines, and the inability to complete research objectives. Research delays also included delays in publishing peer-reviewed articles and the submission of future funding proposals due to lack of data. Chi-square tests of independence revealed no significant differences, $\chi 2(1) = 1.94$, $p = 0.16$, $\Phi = -0.11$, between ECRs (n = 26, 53.1%) and non-ECRs (n = 73, 67.6%). One participant stated, "[there were] significant experimental, field work, and lab analysis delays both within my own space, conducting field work, sending samples to the national labs, and significant delays through the national labs for analysis" (non-ECR tenure-track faculty). Another explained that "most of the activities for my research area were either postponed or canceled" (non-ECR tenure-track faculty). One participant expressed:

> It is very hard to carve out time for my own scholarly pursuits because I am spending so much extra time focusing on project management and logistics and attending meetings. If I could put aside even 5% of my time a week for manuscripts and other writing, I would be much more productive (ECR non-tenure track faculty).

Furthermore, another participant indicated, "our labs were shut down completely and still we cannot bring participants in as we are starting from scratch. I believe it will be 2 years more to get up and running fully again" (non-ECR tenure-track faculty). One participant described:

> Peer-review has been considerably backlogged. With everything going on, people are turning down requests to review and/or taking a very long time to complete reviews. I have one paper which has been under review for 7 months now... Nobody wants to review, so journal articles are getting stuck (ECR tenure-track faculty).

Limited Collaboration and Networking Opportunities. About half (n = 82, 52.2%) of the participants reported challenges related to collaboration and professional networking (e.g., decreased interactions with colleagues, difficulty engaging colleagues in virtual settings, limited networking opportunities at virtual conferences). Chi-square tests of independence revealed no significant differences, $\chi 2(1) = 0.69$, $p = 0.41$, $\Phi = 0.07$, between ECRs (n = 28, 57.1%) and non-ECRs (n = 54, 50.0%). One participant described "[the] lack of in-person, informal relationships that establish community, limited network opportunities, [and] 'water cooler conversations' that are important to research and career growth" (ECR postdoctoral scholar). Another stated that "not being able to attend meetings for projects, professional service, and colleague conferences/symposia definitely hurts productivity and creativity" (non-ECR non-tenure track faculty). One participant expressed:

> It has definitely been more difficult to work on collaborative projects. The work that I have for projects that I currently work on has become more time consuming and has changed in nature because of the pandemic (e.g., spending WAY more time in zoom meetings, having to redo surveys/assessments to be given online; having to work with partners who are changing their services/procedures because of the pandemic, general challenges related to having less administrative support and longer wait-times to communicate with other people on my team) (ECR non-tenure track faculty).

Furthermore, one participant explained, "the limited access to colleagues also made it more difficult because all interactions were done formally via Zoom. Due to limited interactions, more time was spent responding and writing emails than pre-pandemic times" (ECR non-tenure track faculty). Another indicated:

> I am well established enough in my field I am fine having these years without the face-to-face contact building at conferences and other professional events. However, these were essential to advancing my career, so I am certain our junior colleagues have suffered important network building opportunities they can't get back. Even as someone well established, I have certainly missed good opportunities for new projects as well, the impact to that kind of synergy formation is not so tangible but it is very real for scholars (non-ECR tenure-track faculty).

Teaching and Student Demands. More than a third (n = 67, 42.7%) of participants reported challenges with teaching (e.g., converting classes to hybrid and remote platforms) and increased student demands (e.g., requests from students for accommodations and other supports) due to the pandemic. Chi-square tests of independence revealed no significant differences, $\chi 2(1) = 0.44$, $p = 0.51$, $\Phi = -0.05$, between ECRs (n = 19, 38.8%) and non-ECRs (n = 48, 44.4%). One participant stated, "I had to transfer 4 distinct courses to the online format... This greatly reduced my productive research time" (ECR tenure-track faculty). One participant explained that there was "more time spent on teaching and keeping students accountable for their coursework" (ECR tenure-track faculty). Furthermore, another expressed:

> The main barriers were because of needing to figure out how to best teach in these circumstances. It was difficult and very time consuming to figure out how to best serve my students, and there was a lot of hand holding and experimentation that needed to take place when we pivoted to remote in March 2020, but then also when we were partly in person and partly on zoom (that was how I chose to teach in the Fall of 2020 and the Spring of 2021). I teach studio art classes (similar to a hands-on lab), so these in particular were difficult to figure out. Students

> also needed a lot more support, so my email and personal meeting times have increased greatly (ECR tenure-track faculty).

One participant stated, "I spend much more time... seeking information, advising students, trouble-shooting technology, and juggling teaching situations as students are constantly quarantined" (non-ECR tenure-track faculty). Another explained that "teaching was completely a mess, including the evaluation system which [they] still don't understand how it might impact [their] next promotion" (non-ECR tenure-track faculty).

Restricted Access to Research Sites and Populations. A third (n = 54, 34.4%) of participants reported limited access to research sites (e.g., laboratory and archive closures, inability to conduct field work) and populations (e.g., human subjects) resulting from the pandemic. Chi-square tests of independence revealed no significant differences, $\chi 2(1) = 0.18$, $p = 0.67$, $\Phi = -0.03$, between ECRs ($n = 16$, 32.7%) and non-ECRs ($n = 38$, 35.2%). One participant explained, "I do research on couples and use lab-based methods in my research (experimental). I've had to suspend research that uses those methods since March 2020" (non-ECR tenure-track faculty). Another indicated, "we were not able to do human subjects research because I study small group interactions. I had to reframe research questions entirely because of Covid" (ECR postdoctoral scholar). One participant expressed:

> Lab work was extremely disrupted during Covid, and the constant inconsistency and schedule changes reduced my productively dramatically... the constant changes to schedules (based on when I was allowed on campus and in the lab) prevented me from getting into a good rhythm (ECR postdoctoral scholar).

Another participant stated, "my research relies on archival work and the archives have been closed during this period" (non-ECR tenure-track faculty). Furthermore, one participant explained, "I conduct field-based research so new data collection has been nearly impossible. I have had to refocus my work on the examination of extant data" (non-ECR tenure-track faculty).

Funding Interruptions. A quarter (n = 41, 26.1%) of participants reported funding interruptions. Funding interruptions included reductions in time, restricted grant funding spending, and the re-allocation of funds. Chi-square tests of independence revealed no significant differences, $\chi 2(1) = 0.10$, $p = 0.76$, $\Phi = -0.03$, between ECRs ($n = 12$, 24.5%) and non-ECRs ($n = 29$, 26.9%). One participant stated, "we had planning grants and the funders shifted priorities during Covid, so the project was discontinued" (ECR postdoctoral scholar). Another expressed:

> [I] had to pull a grant because [the university] cancelled [summer programming]... [The program] brings in money to fund the rest of the year, [so my] salary was reduced. [I was] not able to establish [the summer program] that could [have] created job stability for future years (ECR non-tenure track faculty).

One participant explained, "many [of my] funders and partners are state and federal agencies that froze programs and reduced funding" (non-ECR non-tenure track faculty). Furthermore, another participant indicated that their "grant period ran out before we could implement planned experiments" (non-ECR non-tenure track faculty). Another stated:

> An existing [name of funder] grant was reduced by ~$100,000 because [university] purchasing and hiring restrictions impacted our ability to recruit staff and purchase needed equipment. As a result, spending was under budget and some funds were reallocated to another institution (non-ECR tenure-track faculty).

4.2.2. Intangible Challenges

Two overarching themes emerged that were categorized as "intangible challenges": (1) mental health and safety concerns and (2) work–life imbalance. Intangible challenges described conceptually dynamic barriers that affected research productivity. Almost three-fourths (n = 111, 70.7%) of participants reported at least one intangible challenge related to the pandemic.

Mental Health and Safety Concerns. Half (n = 78, 49.7%) of the participants reported mental health and safety challenges (e.g., concern for their safety, fear of exposing vulnerable family members to COVID-19) due to the pandemic. The participants also reported increases in anxiety and depression related to isolation and safety concerns. Chi-square tests of independence revealed no significant differences, $\chi 2(1) = 0.33$, $p = 0.57$, $\Phi = 0.05$, between ECRs (n = 26, 53.1%) and non-ECRs (n = 52, 48.1%). As one participant illustrated, "[my] mental health [has] impacted my ability to focus on work: I worry about my safety, child's safety, the well-being of the world" (non-ECR tenure-track faculty). Another expressed:

> The stress associated with the pandemic, rapidly changing and uncertain teaching modalities, and isolation caused a relapse of my major depression and a serious impact on my mental health. This affected my ability to do independent research and manage my research group... The sense of isolation and feelings of being unsafe at work (being asked to teach in-person when I was not comfortable with it) contributed to a sense of disillusionment with [the university] (ECR tenure-track faculty).

One participant explained, "I am constantly worried that I will catch Covid and some underlying condition that I do not know about will have long-term effects on my health. The constant fear is paralyzing" (ECR postdoctoral scholar). Another participant indicated, "I am exhausted, and not able to give 100% to anything. I feel I have very little wellbeing, connection to the community and that my efforts are not valued" (non-ECR non-tenure track faculty).

Work–life Imbalance. Almost half (n = 74, 47.1%) of participants reported work–life imbalance, including interruptions due to the lack of childcare and K-12 remote learning, increased distractions (e.g., no remote workspace), and difficulties in creating boundaries between home and work. Chi-square tests of independence revealed that ECRs (n = 29, 59.2%) were significantly more likely to report work–life imbalance than non-ECRs (n = 45, 41.7%), $\chi 2(1) = 4.15$, $p < 0.05$, $\Phi = 0.16$. One participant stated, "during the initial shutdown period (Mar–May 2020), I experienced heightened distractions while working from home as I have a toddler son. The distractions of home decreased my overall work productivity" (ECR tenure-track faculty). Another participant explained, "working from home included many more distractions, primarily childcare [and] children's education related, than previously. Additionally, I was not able to create a good workspace for myself at home" (ECR tenure-track faculty). One participant stated, "[I was] less productive after a time because I felt like there was no distinction between work time and home time" (non-ECR non-tenure track faculty). Another expressed, "conducting research from home was slower, communication imperfect, and more distractions at home made it harder to complete tasks by deadlines" (non-ECR non-tenure track faculty).

4.3. Long-Term Impacts on Career Trajectory

Over half of participants (n = 83, 54.9%) expressed concerns about the long-term, cumulative impacts of the pandemic on their career trajectory (see Figure 1). This was frequently cited by ECRs whose professional development has been stunted by the pandemic. Chi-square tests of independence revealed that ECRs (n = 31, 63.3%) were significantly more likely to report long-term concerns than non-ECRs (n = 53, 49.1%), $\chi 2(1) = 3.09$, $p < 0.10$, $\Phi = 0.14$. One participant illustrated, "I have not had the time necessary to devote to my research and I fear I will never get back on the trajectory to successful get tenure" (ECR tenure-track faculty). Another stated, "delays in research progress (delays in students starting; greatly increased lead times for equipment; etc.) has meant that I was not able to generate as much momentum as a junior faculty member in my first 1.5+ years" (ECR tenure-track faculty). One participant indicated:

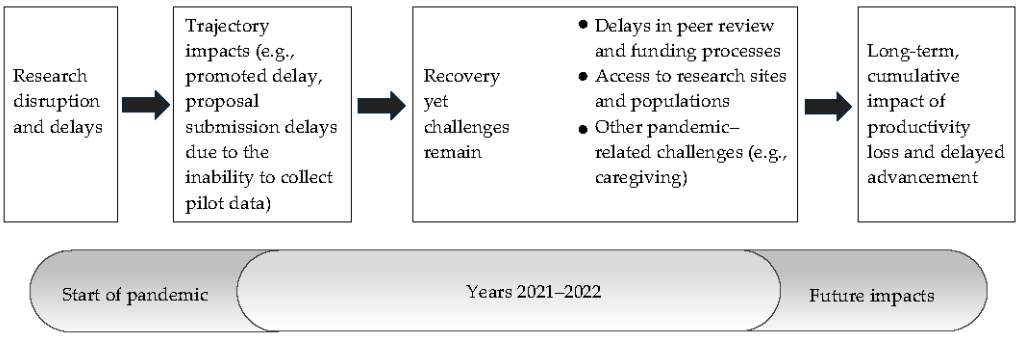


Figure 1. Pandemic-related disruptions to the research pipeline and long-term career impacts.

> I started a new position during Covid. There are still few people on campus and few opportunities for networking and meeting my peers. I fear this will have lasting impacts as I'm not thought of for teaching opportunities, being included on grant submissions, or fully sharing my experience to be included as a co-author where I may be helpful (ECR postdoctoral scholar).

When non-ECRs reported concerns, they were less concerned with their own career trajectory but mentioned concern for their junior colleagues. As one participant explained, "there are long-term effects on early career researchers whose productivity has suffered during Covid-19. Even if Covid were to end tomorrow, it doesn't mean they just snap back. They have to build and re-build after this period of exhaustion" (non-ECR non-tenure track faculty). Another indicated that "the people I'm really worried about are early career people (ex. postdocs). Many early career people are needing to restart their research" (non-ECR non-tenure track faculty). One participant stated that "delays need to be considered when people go up for tenure, [as] junior faculty have been hit harder" (non-ECR tenure-track faculty). Another indicated that "I've already been promoted to professor so that [the inability to conduct human subjects research] doesn't hurt my career aspects significantly, but I know it does for assistant and associate level faculty who are in the same situation" (non-ECR tenure-track faculty).

The initial disruptions to research activities (e.g., inability to collect pilot data) limited the ability to publish findings and apply for funding (Figure 1). As one participant illustrated:

> COVID-19 has severely hampered the progress of my research trajectory, as I have been unable to collect human subjects' data for over a year and continue to be unable to collect the data that I really need in order to write an external grant. The amount of time required to transition courses to alternate modalities and to respond to regular student requests...is substantial, and this takes away from time when I could be writing manuscripts for publication. Thus, it could also have an impact on my potential for getting tenure (ECR tenure-track faculty).

Although participant research outcomes are starting to rebound, challenges cited by participants remain (e.g., delays in the review process for submitted articles and funding proposals, limited access to data due to continued site restrictions, challenges related to personal safety and childcare). Another participant explained:

> I would say overall that Covid-19 has had a serious negative impact on my career trajectory and well-being. I have done the best I possibly can, but I work with child human subjects... recruitment is challenging and near impossible for a group that is unvaccinated (<5 yo). This will pose a lasting impact on my work considering this is an ongoing problem (ECR tenure-track faculty).

The cumulative impacts of pandemic-related productivity loss may result in delayed advancement (e.g., tenure, promotion) and lack of competitiveness for future funding proposals, as one participant elaborated:

> As an academic who is doing research, I worry less about the last year and more about the longevity of my career. At some point, I am going to go up for a grant

against someone who doesn't have children and were able to focus on their work during Covid and I'm not going to get it (ECR tenure-track faculty).

5. Discussion

The findings from the present study mirror pandemic-related challenges across the U.S. (Krukowski et al. 2021; Myers et al. 2020; Rupnow et al. 2020; Viglione 2020). During the pandemic, both ECRs and non-ECRs reported decreases in time spent on research, increases in time spent on teaching, and decreases in the number of peer-reviewed publications and funding proposals submitted. Yet, for ECRs, the cumulative effects of research delays and productivity losses may be more impactful due to their vulnerable position (e.g., job insecurity). Our findings suggest that the pandemic not only hindered the careers of many ECRs but created additional places for ECRs to "leak-out" or leave the pipeline altogether.

5.1. Research Delays and Trajectory Impacts

As shown in Figure 1, the initial stages of the pandemic resulted in research delays that began to negatively affect the career trajectories of many ECRs. For instance, our participants frequently reported that the inability to collect data early in the pandemic inhibited their ability to submit funding proposals and papers for publication. Decreases in research productivity outcomes among ECRs during the pandemic are consistent with the existing research in the U.S. (Andersen et al. 2020; Chim et al. 2023; Harrop et al. 2021; Mayowski et al. 2023; Viglione 2020). Given the necessity of productive scholarship for career retention and advancement, ECRs are likely to be differentially affected compared to colleagues who are more advanced and established in their careers. This placed even higher demands and expectations (e.g., publishing, proposal writing) on ECRs, which can lead qualified faculty and staff to "leak-out" or leave the pipeline (Ferri et al. 2016). Interestingly, although ECRs reported spending more time on research compared to non-ECRs, they reported fewer research productivity outcomes. This finding may reflect the additional intangible challenges reported by ECRs and captured by the qualitative data. For example, the previous research in the U.S. documents that some of the most common challenges for ECRs during the pandemic were intangible, relating to topics such as mental health and work–life imbalance (Chim et al. 2023; Harrop et al. 2021; Mayowski et al. 2023).

5.2. Continuing Challenges

Although time spent on research and teaching started to rebound in year two of the pandemic, our qualitative findings highlight that ECRs still face many of these challenges (see Figure 1). For instance, participants frequently indicated that the review process for publications and funding proposals is "backlogged." These delays make it difficult for ECRs to pursue independent research (Chim et al. 2023; Krukowski et al. 2021; Myers et al. 2020; Tchieu et al. 2020). Furthermore, although many participants reported that they regained entry to their labs or field sites and were able to resume their work, supply chain delays (e.g., equipment, materials) pose ongoing challenges. Our findings also highlight how the collection of data with human subjects was stalled during the pandemic. While some researchers were able to pivot to virtual methods of data collection, others were unable to collect data altogether. Even with the vaccine rollout, there are still ongoing challenges to in-person data collection, including practical barriers (e.g., site relocation, social distancing) and ethical considerations (Harcey et al. 2021).

Finally, our participants frequently reported disruptions related to caregiving responsibilities and K–12 remote schooling, particularly with ongoing school and daycare closures. This challenge is especially important as a lack of reliable childcare disproportionately affects women in their early career phase (Chim et al. 2023; Krukowski et al. 2021; Moschella-Smith and Potter 2024; Myers et al. 2020). While care responsibilities were noted as a "leak" in the pipeline prior to the COVID-19 pandemic (Ferri et al. 2016), our findings highlight the increased caregiving demands among ECRs resulting from remote work

and school. Yet, this continuous work–life imbalance can further lead ECRs, particularly women, to "leak-out" or leave the pipeline altogether.

5.3. Long-Term Career Impacts

Figure 1 demonstrates the cumulative impacts of the pandemic on ECRs' career trajectories. Consistent with the research from the National Institutes of Health, our findings revealed that over 60% of ECRs were concerned about the long-term impact of the pandemic on their career trajectory (Bernard and Lauer 2021). These concerns may explain the slight increase in funding submissions among ECRs during year one of the pandemic, given that they do not have the same job security as non-ECRs. Non-ECRs were less concerned for their own career trajectories, emphasizing that they were "established" in their position when the pandemic began. Instead, non-ECRs expressed concern for their junior colleagues, highlighting that many ECRs needed to restart their research as a result of the pandemic. The lack of job security is a common "leak" in the pipeline; however, the pandemic exacerbated concerns related to job insecurity that can compromise ECRs' long-term career development (e.g., impedes work performance, reduces job satisfaction) (Ferri et al. 2016).

Our findings underscore the need to reframe research productivity in the aftermath of the pandemic in the U.S. (Kemaladewi and Kawaguchi 2021; Sotto-Santiago et al. 2021). One suggestion is to offer tenure clock extensions to account for the research delays and disruptions (Jefferson et al. 2021). Extensions would provide ECRs with the time to apply for additional funding and for publications to undergo the peer-review process. Another possibility is for institutions to incorporate a "Covid-19 professional impact statement" into their evaluations of ECRs (Gonzales and Griffin 2020; Oleschuk 2020; Settles and Linderman 2020). Statements such as these would provide ECRs an opportunity to describe how their research and other work was interrupted by the pandemic. An additional suggestion may be to reduce the weight given to teaching evaluations for courses held during the pandemic due to the abrupt shift to remote learning (Oleschuk 2020). Finally, U.S. universities and grant funding agencies are urged to recognize the long-term, cumulative impact of pandemic-related disruptions to ECRs' research trajectories over the next several years. As suggested by the SCCT, external supports such as these may promote career advancement (e.g., tenure) and retention of ECRs (Ferri et al. 2016; Gregor et al. 2023; Lent 2013; Lent and Brown 2019).

5.4. Limitations

Future research is needed to assess the longitudinal impacts of COVID-19 on ECRs. Our data are limited to participants' recollections as they pertain to the pre-pandemic period and the first year of the pandemic. Due to the timing of data collection, the second year of the pandemic also only captured the first eight months. Additionally, research is needed to further examine the interaction between gender, caregiving, and early career status. This is particularly important as the recent research documents the differential impact on women and caregivers during the pandemic (Cardel et al. 2020; Collins et al. 2021; Cui et al. 2022; Moschella-Smith and Potter 2024; Power 2020). Future research is also needed to examine how position type (e.g., postdoctoral scholars, clinical and research faculty) affected research and teaching responsibilities during the pandemic. While we did not have a large enough sample to examine ECRs and position type, it is possible that some of our findings related to teaching were explained by the inclusion of faculty and staff in non-teaching roles.

Additional research should examine other factors (e.g., departmental support) that may impact the career trajectories of ECRs (Dunn et al. 2022; Saw et al. 2020). Furthermore, given that research often results in responses from those more negatively impacted than others, future research is needed that compares self-reported data with actual counts of publications and grant submissions. Finally, participants were recruited from one northeastern university in the U.S. While the sample used in this study is representative of

the university it was collected from, the sample was fairly homogenous. Therefore, more research is needed to examine the impact of additional demographic variables (e.g., racial and ethnic identity, immigration status) on ECRs (Berheide et al. 2022; Chim et al. 2023; Staniscuaski et al. 2021).

6. Conclusions

The COVID-19 pandemic has resulted in productivity losses, particularly for ECRs who do not have the same track record as their non-ECR colleagues (Krukowski et al. 2021; Myers et al. 2020; Rupnow et al. 2020; Sotto-Santiago et al. 2021; Viglione 2020). Our findings show that both ECRs and non-ECRs reported decreases in time spent on research, increases in time spent on teaching, and decreases in the number of peer-reviewed publications and funding proposals submitted during the pandemic. However, compared to non-ECRs, ECRs reported significantly fewer peer-reviewed publications and funding proposal submissions. The cumulative effects of these productivity losses have delayed future career endeavors (e.g., tenure, promotion) for many ECRs. Universities should implement strategies to mitigate the adverse impacts of the pandemic and address the specific needs of ECRs in the U.S.

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Notes

[1] The current study was conducted in the United States. Although various regions across the globe conceptualize research and research productivity differently, our manuscript focuses primarily on the United States and other regions in the Global North (Brew 2001; Bowden et al. 2005; Heng et al. 2022; Xie and Postlethwaite 2019).

[2] The present study defines ECRs as researchers at the postdoctoral level or faculty and staff within the first five years of their position after earning a doctoral degree.

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