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ORIGINAL RESEARCH/SCHOLARSHIP

Principal Investigators' Priorities and Perceived Barriers and Facilitators When Making Decisions About Conducting Essential Research in the COVID-19 Pandemic

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Abstract

At the onset of the COVID-19 pandemic in the United States, stay-at-home orders disrupted normal research operations. Principal investigators (PIs) had to make decisions about conducting and staffing essential research under unprecedented, rapidly changing conditions. These decisions also had to be made amid other substantial work and life stressors, like pressures to be productive and staying healthy. Using survey methods, we asked PIs funded by the National Institutes of Health and the National Science Foundation (N = 930) to rate how they prioritized different considerations, such as personal risks, risks to research personnel, and career consequences, when making decisions. They also reported how difficult they found these choices and associated symptoms of stress. Using a checklist, PIs indicated those factors in their research environments that made their decisions easier (i.e., facilitators) or more difficult (i.e., barriers) to make. Finally, PIs also indicated how satisfied they were with their decisions and management of research during the disruption. Descriptive statistics summarize PIs' responses and inferential tests explore whether responses varied by academic rank or gender. PIs overall reported prioritizing the well-being and perspectives of research personnel, and they perceived more facilitators than barriers. Early-career faculty, however, rated concerns about their careers and productivity as higher priorities compared to their senior counterparts. Early-career faculty also perceived greater difficulty and stress, more barriers, fewer facilitators, and had less satisfaction with their decisions. Women rated several interpersonal concerns about their research personnel more highly than men and reported greater stress. The experience and perceptions of researchers during the COVID-19 pandemic can inform policies and practices when planning for future crises and recovering from the pandemic.

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Introduction

During the spring of 2020, state and local governments began issuing stay-at-home orders in response to the COVID-19 pandemic (Moreland et al., 2020). Research institutions responded by allowing only research activities deemed "essential" to continue on-site and requiring all other research activities to be suspended or performed remotely. With this rapid transition to essential-only research, principal investigators (PIs) had to quickly interpret and act on the mandates issued by their institutions. We use the term "PIs" and "faculty" interchangeably throughout to indicate any researcher who leads a research team and is the individual ultimately responsible for the oversight, design, conduct, and reporting of scientific research. PIs had to make critical and challenging decisions, such as what research projects and activities were essential and who would conduct research on-site, amid uncertainty and stress and often with limited time and guidance. The decisions PIs faced had numerous implications, including their impact on graduate students, postdocs, and other personnel, their impact on the PIs themselves, and consequences for research productivity.

These competing concerns put PIs in the position of making decisions with ethical implications (Antes et al., 2019b; Brown & Trevino, 2006; Messick & Bazerman, 1996). PIs' decisions posed personal and professional risks to research personnel and to themselves. Many researchers had to shift to research activities that could be done from home (e.g., paper writing, data analysis) or suspend their research altogether, potentially stunting career progression. On the other hand, when conducting research on-site, researchers took on risks to themselves and their families, especially in early stages of the pandemic when the transmissibility and severity of the disease was unknown. Other personal priorities included maintaining their own health, as well as the health of loved ones. Researchers also likely felt pressure to maintain scholarly productivity and an obligation to protect and advance science. For example, concerns existed around maintaining animal subjects or other research materials (e.g., preserving reagents, deciding whether to preserve or euthanize animal subjects) and continuing to make progress toward scientific aims. In sum, when making decisions about conducting and staffing essential research, PIs encountered choices that affected science, careers, and personal lives all amid uncertainty about how long labs might be operating with limited capacity or the long-term consequences of their decisions.

The purpose of this study was to understand what PIs prioritized and the barriers and facilitators they perceived to making decisions, such as conflicting institutional guidance about ramping down research operations (Wigginton et al., 2020), or institutional guidance that was communicated quickly. The study also investigated how PIs felt about their decisions in terms of their difficulty and associated stress, and their satisfaction with their decisions and management of research personnel during the disruption.

We examined whether responses differed by academic rank, anticipating that PIs earlier in their careers may have experienced unique challenges that influenced their decisions and perceptions (Harrop et al., 2021; Kliment et al., 2021). Existing evidence also indicates women researchers, particularly those with children, were differentially impacted by the pandemic, especially with respect to productivity (Cui et al., 2021; Myers et al., 2020). Therefore, we explored whether gender differences existed in prioritization, perceived barriers and facilitators, and PIs' self-assessment of the difficulty of decisions, stress, and satisfaction with how they handled the crisis.

By characterizing PIs' experiences, we hoped to inform policies and practices to prepare and support PIs in future emergencies that disrupt research. Using survey methods, we invited PIs to share how they navigated making decisions at the onset of the COVID-19 pandemic. The survey also allowed us to describe the nature of the essential research that was conducted. Our guiding research questions included:

1. What did PIs prioritize most when making decisions about conducting and staffing on-site essential research at the onset of the COVID-19 pandemic?
2. How difficult did PIs perceive these decisions, and what, if any, corresponding symptoms of stress did they experience?
3. What barriers and facilitators to decision-making did PIs perceive?
4. How satisfied were PIs with their decisions and management of personnel?
5. Did PIs' responses vary according to academic rank or gender?

Methods

Our team developed and administered a national survey of PIs to understand their views and experiences with making decisions about staffing and conducting on-site essential research at the onset of the COVD-19 pandemic. We used descriptive and inferential statistics to understand participant views and determine the existence and extent of sub-group differences. The Washington University in St. Louis Institutional Review Board approved this research (#202006012).

Recruitment and Procedure

This study used a non-probability criterion-based sampling approach, which was necessary because there is no way to identify and target only the PIs who had continued on-site research at the onset of the stay-at-home orders. We used publicly available grant award data from the National Institutes of Health (NIH) RePORTER and National Science Foundation (NSF) Award Search databases to identify all actively-funded PIs and their publicly available email addresses. All NIH PIs were included in the recruitment database. For NSF, we included PIs funded by the biological, social, behavioral, and economic sciences directorates, and the chemistry and materials research divisions within the directorate for mathematical and physical sciences. We sent the recruitment email to just over 20,000 PIs. We cannot

determine a precise response rate, as we are unaware of the total proportion of investigators contacted who continued essential research.

We aimed to enroll at least N = 800 PIs and succeeded in enrolling 930 participants. We initially estimated this target sample size based on samples that were adequate to detect moderate effect sizes in our past studies of researchers (Antes et al., 2016, 2018, 2019a; Solomon et al., 2022). We planned to examine three academic rank subgroups and wanted to ensure representation of a range of scientific disciplines and institutions and PIs funded by NIH and NSF. Therefore, we estimated that 200–300 per group (N = 600–900 total) would provide for adequate representation and power. Formal power analyses confirmed this range was appropriate. Power analysis for point estimates assuming a margin of error of 0.10 and a SD of 0.75 suggested a sample size of 215 per group would be adequate, and a SD of 1.0 indicated a sample of 380 per group would be adequate. We selected 800 as our target sample size.

The recruitment email indicated the study's purpose, eligibility criteria, and a link to the confidential survey administered using Qualtrics survey software. Data were collected between September and November 2020. The survey took approximately 15–20 min. The requirement for documentation of consent was waived by the IRB. At the start of the survey, participants were provided with an information sheet about the study and answered a screening question to ensure eligibility. The screening question asked if they and/or any research personnel conducted on-site research or maintenance (e.g., feeding animal subjects, maintaining samples) activities at any point during the stay-at-home orders issued in the early months of the pandemic. The survey instructed participants to report on the disruption of research operations in spring of 2020 when stay-at-home orders were implemented. Upon completion of the survey, participants were asked if they wished to enter a raffle for a $100 gift card for participating. If they did wish to be entered into the raffle, they were redirected to a separate survey that asked for their contact information so that it would remain separate from their survey data.

Within the recruitment email, PIs were asked to invite their research personnel to share their experiences via a separate confidential survey link. We report on these findings in the supporting information (S1 Appendix).

Survey Development

We are a team of social scientists with expertise in the fields of research ethics, workplace psychology, and measurement. We developed survey questions using our lived experience as federally-funded investigators, members of research ethics boards, and directing programs in research integrity. Additionally, our prior research on researchers and research lab environments focusing on the leadership and management of research teams, ethical decision-making, and responsible conduct of research, informed item generation (Antes et al., 2016 Antes et al., 2019b; Antes et al., 2019c; Bruton et al., 2020; McIntosh et al., 2020; McIntosh et al., 2021; Solomon et al., 2022). A pool of items was drafted and iteratively revised, followed by feedback from 8 PIs who continued essential on-site

research. We contacted researchers through our networks who are in varied scientific disciplines at private and public institutions in different regions of the U.S., ensuring that different genders and ranks were represented. We asked the PIs to review the clarity and comprehensiveness of survey items and revised according to their feedback.

There were 22 items asking participants about their research discipline, research institution, funding agency, state, and lab size. Participants were also asked about the transition to essential-only research, such as how much time they had to make this shift and whether they were required to submit a written plan. Participants were asked to rate their agreement (1, *strongly disagree* to 7, *strongly agree*) regarding the clarity of their institution's definition of "essential research," the ease of determining on-site research staffing, and their confidence in decisions about conducting and staffing research.

PIs were presented with 20 statements of possible considerations when making decisions about conducting and staffing on-site research. They were asked to rate which considerations they prioritized as most important in their decision making (1, *not all important* to 5, *extremely important*). If a consideration was not relevant to their research (e.g., animal research considerations when they did not conduct animal research), participants could choose the response option of "N/A" (i.e., "not applicable"). Cronbach's alpha measure of internal consistency ($\alpha = 0.87$) indicated very good scale reliability.

After rating the considerations, participants were asked: "Overall, how difficult was it to prioritize all of these factors in making decisions about conducting and staffing on-site research activities?" The scale was 1 (*not at all difficult*) to 5 (*extremely difficult*). Participants responding 2 (*slightly difficult*) to 5 (*extremely difficult*) were asked "how did these difficult decisions affect you?" The item presented a checklist of 6 symptoms of stress (e.g., loss of sleep, feeling anxious) (Amirkhan et al., 2018), and participants checked all that applied. Kuder-Richardson Formula 20 to examine internal consistency for these 6 binary variables indicated adequate reliability (KR-20 = 0.62). An "other" option allowed participants to write in other effects of stress.

Participants were asked to indicate using a checklist (i.e., yes/no) if they had experienced any of 13 barriers to making decisions about conducting and staffing essential on-site research. We defined barriers as factors that made decisions more difficult to make. Internal consistency for the barriers items was good (KR-20 = 0.70). Next, they completed a checklist of 13 facilitators to indicate whether they experienced each facilitator. We defined facilitators as factors that made decisions easier to make. Internal consistency for the facilitators items was very good (KR-20 = 0.83). Both sections included an open-ended question asking participants to add and describe any other barriers or facilitators they experienced.

A section of 7 items asked participants to indicate their agreement (1, *strongly disagree* to 7, *strongly agree*) with statements regarding satisfaction with their decisions and management of research on-site and from home. Cronbach's alpha measure of internal consistency ($\alpha = 0.87$) indicated very good scale reliability. Participants indicated their race, ethnicity, and gender, and they described their institution and research role (e.g., academic rank, number of years as faculty, discipline).

Data Analysis

Data were analyzed using statistical software (IBM SPSS, Version 27.0). We examined descriptive statistics (i.e., means and standard deviations, or counts and percentages) to characterize our findings. We describe the characteristics of the PIs and the "essential" research they conducted. Next, we describe the importance reported by PIs for each consideration, perceptions of difficulty with prioritizing these considerations, symptoms of stress, barriers and facilitators, and satisfaction with their decisions. We examine results overall among all PIs and by academic rank (assistant, associate, and full professor).

We examined if the mean scores differed by academic rank by performing a series of between-subjects analysis of variance (ANOVA) tests with rank as the independent variable and each priority or perception item as the dependent variable. When the omnibus ANOVA F-test was statistically significant, we performed post hoc pairwise t-tests (between-subjects and two-tailed) with Bonferroni corrections for multiple testing to identify which specific academic ranks differed.

We analyzed barriers and facilitators by academic rank by performing chi-square tests of independence to examine the relation between rank and each barrier or facilitator. If the omnibus chi-square test was statistically significant, we followed up with Bonferroni adjusted z-tests for independent proportions to discern which specific groups differed. We report statistically significant omnibus tests in the narrative and illustrate the significant differences by rank using notation in the tables.

We also explored whether PIs' responses regarding priorities, perceptions, and barriers/facilitators differed by gender using t-tests and chi-square analyses, and report differences where they emerged. Finally, we examined whether the effects of rank remained after controlling for gender to account for differences in gender distributions by rank. To do this, we added gender as a covariate in the ANCOVA analyses for continuous outcomes, and tested rank and gender simultaneously as predictors of dichotomous dependent variables using logistic regression.

To prepare the data for analysis, we excluded PIs (N = 162) who did not complete at least one key section of survey items and removed PIs (N = 330) who screened out. The final sample size was 930 PIs. We indicate item-specific sample sizes throughout the results, as participants were permitted to skip items and some items included a "not applicable" option.

Results

Participants

We report the characteristics of the PIs ($N = 930$) in Table 1. On average, PIs reported they had been doing research as faculty for about 17 years ($M = 16.78$, $SD = 9.90$, $n = 890$). Years of experience by rank included: assistant professors ($M = 5.15$, $SD = 2.56$, $n = 134$), associate professors ($M = 11.02$, $SD = 4.67$, $n = 251$), and full professors ($M = 22.94$, $SD = 8.29$, $n = 474$). PIs indicated their research groups typically had about 10 ($M = 9.59$, $SD = 6.61$, $n = 929$) research personnel

Table 1 Characteristics of principal investigators

	Count	%
Funding Agency		
NSF	261	28
NIH	557	60
Both NSF and NIH	112	12
Academic Rank (N = 892)		
Assistant professor	134	15
Associate professor	251	28
Full professor	477	54
Other (e.g., institute director; senior scientist)	30	3
Tenured (N = 891)		
Yes	629	71
No	262	29
Discipline		
Social sciences	26	3
Health sciences	189	20
Biological sciences	587	63
Physical sciences	102	11
Other (e.g., engineering; environmental science; plant virology)	26	3
Research Institution Type (N = 929)		
Academic medical center	362	39
Liberal arts college	26	3
Private university	143	15
Public university	359	39
Other (e.g., private research institute; non-profit research institution)	39	4
Primary Faculty Appointment (N = 892)		
Medical school	404	45
Arts and Sciences	306	34
Engineering	72	8
Other (e.g., agriculture, dental school; pharmacy school; veterinary school)	110	12
% of salary expected to cover with external funding (N = 889)		
Less than 25%	380	43
26–50%	183	21
51–75%	182	21
76–100%	144	16
Gender (N = 893)		
Male	484	54
Female	385	43
Other or prefer not to answer	24	3
Race (check all that apply) (N = 898)		
American Indian or Alaska Native	4	< 1
Asian	143	16
Black or African American	9	1

Table 1 (continued)

	Count	%
Native Hawaiian or Other Pacific Islander	0	0
White	669	75
Prefer not to answer	78	9
Ethnicity (N = 892)		
Latino/Hispanic	33	4
Not Latino/Hispanic	789	89
Prefer not to answer	70	8

N = 930, unless otherwise indicated

(i.e., undergraduates, graduate assistants, staff, postdocs, or junior faculty). The PIs' institutions ($n = 914$) were located in the United States across the midwest (22%), northeast (24%), south (29%), and west (25%).

We examined the distributions of academic rank by gender. This analysis indicated that among assistant professors, women (n = 65, 50%) and men (n = 66, 50%) were evenly distributed. Gender was not equally represented among associate professors (n = 109, $45\%_{\text{women}}$; n = 135, $55\%_{\text{men}}$) or full professors (n = 195, $42\%_{\text{women}}$; n = 268, $58\%_{\text{men}}$). The findings for academic rank hold after controlling for gender on the following variables: priorities when making decisions, difficulty with prioritizing, sum of stress symptoms, barriers, facilitators, and satisfaction with their decisions. The exception was for specific symptoms of stress, as described in a subsequent section of the results.

Description of Essential Research

PIs indicated the type(s) of essential research their group conducted on-site, selecting all that applied: wet lab research (54%, n = 499), animal subjects research (51%, n = 475), dry lab or computation research (15%, n = 143), "other type" (e.g., field research and lab plant research) (15%, n = 138), clinical research with human subjects (9%, n = 79), and social/behavioral research with human subjects (3%, n = 28). The most common essential research activities (reported as "select all that apply") included: maintaining animal subjects (51%, n = 471), performing experiments (46%, n = 429), maintaining specimens or laboratory materials (48%, n = 443), maintaining laboratory equipment (41%, n = 381), "other essential research activities" (e.g., maintaining plants) (13%, n = 124), and collecting data from human subjects (9%, n = 81). Of the research conducted, 22% (n = 204) reported that their work was related to COVID-19 or SARS-CoV-2. On average, PIs (N = 930) indicated moderate agreement that their institution's definition of "essential research" was clear (M = 5.12 on a 7-point scale); however there was noteworthy variance on this item (SD = 1.67). They also indicated they had, on average, about 7 days (M = 7.40, SD = 8.22, n = 889) to make the transition to conducting only essential research. Additional details about the transition and staffing of essential research are provided in supporting information (S2 Appendix).

PI Priorities

The PIs' overall ratings of importance for the considerations are reported in descending order in Table 2. The pattern indicates a focus on the health and safety of personnel, how personnel felt about conducting on-site research, and making the right decisions for personnel. Also highly prioritized by PIs was the health and safety of the people they lived with. The PI's personal health and safety occupied a position in the middle of the list, below prioritizing the needs of people in their personal life, providing emotional support to personnel, and impact on human and animal research subjects.

There were differences for 6 considerations when comparing assistant, associate, and full professors. These considerations included: needs of people in their personal life, $F(2, 806) = 7.63$, $p < 0.001$, risks to future research funding, $F(2, 851) = 7.53$, $p < 0.001$, research productivity, $F(2, 854) = 7.87$, $p < 0.001$, concerns about following institutional policy, $F(2, 789) = 7.28$, $p < 0.001$, leaders viewing their decisions favorably, $F(2, 844) = 4.61$, $p = 0.01$, and negative career impact, $F(2, 842) = 40.47$, $p < 0.001$.

Assistant and associate professors rated the needs of people in their personal lives higher than did full professors. Assistant and associate professors also rated risk to future funding, declines in productivity, and being criticized if they did not follow institutional policy as weighing more strongly in their decisions than full professors. Assistant professors compared to associate and full professors rated one consideration higher: whether institutional leaders would view their decisions favorably. The long-term negative impact on their career differed among all groups, with assistant professors rating this consideration highest followed by associate professors and then full professors.

We identified four considerations that women rated as higher priorities than men did. Women (n = 378) reported placing greater priority on making the right decisions for personnel than men (n = 473), $t(849) = 2.95$, $p = 0.003$; $M_{women} = 4.24$, $SD = 0.82$, $M_{men} = 4.06$, $SD = 0.90$. Women (n = 377) prioritized how personnel felt about conducting on-site research more than men (n = 475), $t(850) = 2.56$, $p = 0.011$; $M_{women} = 4.22$, $SD = 0.84$, $M_{men} = 4.07$, $SD = 0.87$. Women (n = 377) rated providing emotional support to personnel as a higher priority than men (n = 474), $t(849) = 4.31$, $p < 0.001$; $M_{women} = 3.96$, $SD = 0.90$, $M_{men} = 3.66$, $SD = 1.05$. Finally, women (n = 330) prioritized concerns about financial impact on personnel higher than men (n = 439), $t(767) = 2.97$, $p = 0.003$; $M_{women} = 3.81$, $SD = 1.11$, $M_{men} = 3.55$, $SD = 1.21$).

PI Perceptions of Difficulty with Prioritizing and Symptoms of Stress

The mean difficulty rating reflects that, on average, PIs perceived moderate difficulty with prioritizing different considerations when making decisions, as shown in Table 3. Just 13% of PIs responded "not at all difficult" when asked how difficult it was to prioritize the different considerations. Everyone who experienced

Table 2 Principal investigator priorities when making decisions about conducting essential research

Priority	All PIs			Assistant Prof.[A]			Associate Prof.[B]			Full Prof.[C]		
	M	SD	N	M	SD	N	M	SD	N	M	SD	N
The health and safety of my research personnel while conducting on-site research	4.63	0.62	914	4.62	0.65	133	4.61	0.67	243	4.65	0.58	471
How my research personnel felt about conducting on-site research	4.15	0.86	909	4.15	0.85	132	4.06	0.92	241	4.18	0.83	471
The health and safety of those I live with	4.14	1.03	870	4.22	0.94	124	4.26	1.00	235	4.06	1.06	448
Whether I was making the right decisions for my research personnel	4.14	0.87	911	4.15	0.90	132	4.14	0.91	244	4.17	0.84	469
The potential for animal subjects to be negatively impacted	3.98	1.04	537	4.01	0.94	72	4.07	1.00	156	3.94	1.09	264
The possibility for my research personnel to be delayed in their professional advancement	3.81	1.01	900	3.78	1.01	128	3.74	1.05	242	3.87	0.99	463
How to provide emotional support to my research personnel	3.79	1.00	908	3.87	0.90	132	3.75	1.04	245	3.82	1.01	468
The needs of people in my personal life[A.C†, B.C]	**3.76**	**1.16**	**872**	**3.94**	**1.07**	**126**	**3.97**	**1.07**	**234**	**3.64**	**1.21**	**449**
The potential for my human research participants to be negatively impacted	3.70	1.32	229	3.72	1.37	25	3.82	1.22	50	3.68	1.33	133
The financial impact of my decisions on my research personnel	3.66	1.18	827	3.79	1.13	121	3.71	1.15	218	3.59	1.20	425
My personal health and safety	3.57	1.21	909	3.75	1.19	132	3.64	1.20	245	3.49	1.22	465
The chance to contribute to a solution for COVID-19 crisis	3.41	1.41	451	3.33	1.38	69	3.43	1.35	116	3.40	1.44	231
The potential for future research funding to be at risk[A.C†, B.C]	**3.36**	**1.25**	**920**	**3.52**	**1.17**	**133**	**3.52**	**1.19**	**250**	**3.19**	**1.29**	**471**
How my decisions might impact the working relationships among my research personnel	3.18	1.23	896	3.22	1.19	131	3.05	1.23	242	3.19	1.24	459
The potential for my research productivity to decline[A.C, B.C]	**3.14**	**1.18**	**923**	**3.35**	**1.08**	**134**	**3.27**	**1.17**	**251**	**2.99**	**1.19**	**472**
Whether members of my research group would view my decisions favorably	3.05	1.18	910	3.05	1.12	133	2.98	1.18	243	3.05	1.18	468
Whether I would be criticized if my decisions did not follow institutional policy[A.C, B.C†]	**2.92**	**1.28**	**852**	**3.19**	**1.20**	**125**	**3.05**	**1.25**	**230**	**2.77**	**1.29**	**437**
Whether leaders at my institution (e.g., department chair, research administrators) would view my decisions favorably[A.C]	**2.53**	**1.17**	**912**	**2.80**	**1.12**	**132**	**2.50**	**1.19**	**247**	**2.45**	**1.17**	**468**
The potential negative impact on my career in the long-term[A.B, A.C, B.C]	**2.52**	**1.25**	**909**	**3.18**	**1.21**	**134**	**2.71**	**1.23**	**249**	**2.21**	**1.14**	**462**
The opportunity to pursue available COVID research funding	2.37	1.39	440	2.40	1.32	68	2.38	1.46	111	2.31	1.40	227

PI principal investigator, *Prof.* professor, *M* mean (on a scale of 1 [*not at all important*] to 5 [*extremely important*]), *SD* standard deviation

The academic rank variable compares Assistant, Associate, and Full Professors (n = 30 participants selected "other" in response to the rank item and are removed from these comparisons)

Bold indicates that the omnibus ANOVA F-test for academic rank was statistically significant (see narrative for results). All Bonferroni-adjusted post hoc t-tests are statistically significant at the $p < .01$ level, except where noted. Superscripts indicate which groups differ (e.g., A.C = Assistant Professors differ from Full Professors.)

[†]Comparison $p < .05$

Table 3 Principal investigator perceptions of difficulty with prioritizing and number of stress symptoms

	All PIs			Assistant Prof.[A]			Associate Prof.[B]			Full Prof.[C]		
	M	SD	N	M	SD	N	M	SD	N	M	SD	N
Difficulty with prioritizing[†A.C, B.C‡]	**2.88**	**1.12**	**930**	**3.17**	**1.13**	**134**	**2.97**	**1.06**	**251**	**2.74**	**1.13**	**477**
Sum of stress symptoms[§B.C]	**2.31**	**1.51**	**807**	**2.43**	**1.42**	**122**	**2.65**	**1.54**	**223**	**2.07**	**1.47**	**399**

PI principal investigator, *Prof.* professor, *M* mean, *SD* standard deviation

The academic rank variable compares Assistant, Associate, and Full Professors (n = 30 participants selected "other" in response to the rank item and are removed from these comparisons)

Bold indicates that the omnibus ANOVA F-test for academic rank was statistically significant (see narrative for results). All Bonferroni-adjusted post hoc t-tests are statistically significant at the $p < .01$ level, except where noted. Superscripts indicate which groups differ (e.g., A.C = Assistant Professors differ from Full Professors.)

[†]On a 1 (*not at all difficult*) to 5 (*extremely difficult*) scale

[‡]Comparison $p < .05$

[§]On a 0–7 scale (the range of sums was 0–7)

any level of difficulty with prioritizing (n = 807) completed a checklist of 7 stress symptoms, with the average number of symptoms reported being over 2 (Table 3). Difficulty with prioritizing, $F(2, 859) = 9.19$, $p < 0.001$, and symptoms of stress, $F(2, 741) = 11.48$, $p < 0.001$, differed by academic rank. Assistant professors reported the greatest difficulty prioritizing the different considerations, and associate professors reported the most symptoms of stress.

We also found that women (n = 327) reported more symptoms of stress (M = 2.70, SD = 1.45) than men (n = 424, M = 2.03, SD = 1.48), $t(749) = 6.18$, $p < 0.001$. These effects hold after controlling for rank, $F(1, 719) = 34.71$, $p < 0.001$. However, it is of note that women (n = 385, M = 2.87, SD = 1.17) and men (n = 484, M = 2.87, SD = 1.07) rated difficulty with prioritizing equally.

The symptoms of stress experienced by PIs are shown in Table 4. Common "other effect" responses not listed in Table 4 included weight gain, working more hours, exhaustion, and feeling depressed, angry, or overwhelmed. Overall, the most common symptoms reported included feeling anxious, loss of sleep, and trouble concentrating. There was a significant relationship between academic rank and 5 of the symptoms: feeling anxious, X^2 (2, N = 744) = 8.09, $p = 0.018$, loss of sleep, X^2 (2, N = 744) = 16.47, $p < 0.001$, trouble concentrating, X^2 (2, N = 744) = 17.04, $p < 0.001$, physical symptoms, X^2 (2, N = 744) = 10.10, $p = 0.006$, and loss of appetite, X^2 (2, N = 744) = 12.80, $p = 0.002$.

Women (n = 327) were more likely than men (n = 424) to report feeling anxious, X^2 (1, N = 751) = 31.88, $p < 0.001$, $86\%_{women}$ vs. $68\%_{men}$; loss of sleep, X^2 (1, N = 751) = 13.10, $p < 0.001$, $61\%_{women}$ vs. $48\%_{men}$; trouble concentrating, X^2 (1, N = 751) = 15.32, $p < 0.001$, $56\%_{women}$ vs. $41\%_{men}$; consuming more alcohol or substances, X^2 (1, N = 751) = 4.44, $p = 0.035$, $25\%_{women}$ vs. $18\%_{men}$; and physical symptoms, X^2 (1, N = 751) = 15.11, $p < 0.001$, $25\%_{women}$ vs. $14\%_{men}$.

Table 4 Principal investigator symptoms of stress

	All PIs		Assistant Prof.[A]	Associate Prof.[B]	Full Prof.[C]
	Count (%)	N	Count (%)	Count (%)	Count (%)
Feeling anxious[A.C]	**609 (75)**	**807**	**101 (83)**	**176 (79)**	**286 (72)**
Loss of sleep[A.B, B.C]	**426 (53)**	**807**	**59 (48)**	**144 (65)**	**193 (48)**
Trouble concentrating[A.C, B.C]	**386 (48)**	**807**	**70 (57)**	**123 (55)**	**163 (41)**
Consuming more alcohol or substances	170 (21)	807	26 (21)	48 (22)	77 (19)
Physical symptoms[B.C] (e.g., stomach ache, chest pain, muscle tension)	**150 (19)**	**807**	**23 (19)**	**56 (25)**	**59 (15)**
Loss of appetite[B.C]	**69 (9)**	**807**	**9 (7)**	**32 (14)**	**24 (6)**
Other effect	51 (6)	807	8 (7)	13 (6)	25 (6)

PI principal investigator, *Prof.* professor

The academic rank variable compares Assistant, Associate, and Full Professors. Comparisons exclude participants who selected "other" in response to the rank item or did not report rank. The sample size for academic rank on these items was as follows: Assistant Professors (n = 122), Associate Professors (n = 223), and Full Professors (n = 399)

Bold indicates that the chi-square test for the relationship of academic rank and the symptom of stress was statistically significant (see narrative for results). All Bonferroni-adjusted post hoc z-tests for column proportions are statistically significant at $p < .05$ level. Superscripts indicate which groups differ (e.g., A.C = Assistant Professors differ from Full Professors.)

Using logistic regression to examine rank and gender simultaneously as predictors of stress symptoms (N = 722) revealed that both rank and gender effects hold for feeling anxious, loss of sleep, and trouble concentrating. Controlling for gender, the odds of feeling anxious increased by 46% for assistant professors compared to full professors (OR = 0.54, 95% CI [0.31, 0.92], $p = 0.023$). Controlling for rank, the odds of feeling anxious increased by 63% for women compared to men (OR = 0.37, 95% CI [0.25, 0.54], $p < 0.001$). Controlling for gender, being an assistant professor was a protective factor for loss of sleep—with the odds of loss of sleep decreasing by 100% for assistant professors compared to associate professors (OR = 2.00, 95% CI [1.26, 3.16], $p = 0.003$). Controlling for rank, the odds of loss of sleep increased by 44% for women compared to men (OR = 0.56, 95% CI [0.41, 0.76], $p < 0.001$).

Controlling for gender, the odds of trouble concentrating increased by 48% for assistant professors compared to full professors (OR = 0.52, 95% CI [0.34, 0.79], $p < 0.002$). Controlling for rank, the odds of trouble concentrating increased by 44% for women compared to men (OR = 0.56, 95% CI [0.42, 0.76], $p < 0.001$). For physical symptoms, only gender remained a significant predictor. Controlling for rank, the odds of physical symptoms increased by 51% for women compared to men (OR = 0.49, 95% CI [0.33, 0.71], $p < 0.001$). Rank effects for loss of appetite became only marginally significant when controlling for gender, and being an assistant professor was protective, with the odds of loss of appetite decreasing by 114% for assistant professors compared to associate professors (OR = 2.14, 95% CI [0.98, 4.66], $p = 0.055$).

Perceived Barriers to Decision-making

The perceived barriers among PIs are reported in descending order in Table 5. The average number of perceived barriers among all PIs was nearly 4 (M = 3.70, SD = 2.65, n = 920) out of 13 we presented in the checklist.

There were 2 barriers that were perceived by 15% or fewer of PIs. Sizable proportions of PIs, ranging from 19 to 50%, experienced the remaining 11 barriers. The most common barriers perceived, regardless of academic rank, pertained to struggles with personnel and institutional guidance. PIs had greater difficulty making decisions when personnel had childcare limitations or were at high risk for COVID-19 complications. PIs also struggled when the institutional guidance provided was too vague or contradictory. There were also concerns about access to resources and guidance related to safety, along with lack of guidance generally and guidance that did not fit with the PIs' particular type of research.

There was a significant relationship between academic rank and four barriers: lack of resources for protecting personnel, X^2 (2, N = 853) = 6.86, $p = 0.032$, lack of institutional guidance, X^2 (2, N = 853) = 24.97, $p < 0.001$, lack of institutional guidance regarding safety, X^2 (2, N = 854) = 21.55, $p < 0.001$, and guidance that provided too much discretion, X^2 (2, N = 853) = 19.74, $p < 0.001$. A greater proportion of assistant professors compared with full professors felt they lacked safety resources and had too much discretion. While a minority of assistant professors felt having too much personal discretion was a barrier (19%), this perception was much higher among assistant professors than more experienced full professors (7%). A greater proportion of assistant professors compared with associate and full professors perceived a general lack of institutional guidance and lack of guidance related to the safety of personnel.

Only two barriers differed by gender. Women (n = 382) were more likely than men (n = 478) to indicate personnel at high-risk for COVID-19 complications was a barrier, X^2 (1, N = 860) = 11.59, $p < 0.001$, $54\%_{\text{women}}$ vs. $42\%_{\text{men}}$. Women (n = 381) were also more likely than men (n = 479) to indicate lack of guidance regarding keeping personnel safe was a barrier, X^2 (1, N = 860) = 3.87, $p = 0.049$; $24\%_{\text{women}}$ vs. $18\%_{\text{men}}$.

Open-Ended Barriers Reported by PIs

Additional barriers were provided as open-ended responses by nearly 300 respondents (N = 288). We analyzed these responses using content analysis. A research assistant reviewed responses for themes and categorized them, repeating this process until all responses were classified. This process was supervised and reviewed by ALA. Novel barriers that were not included in the checklist included those encountered by the PIs directly, those focused on issues with personnel, those related to the behavior of peers, those at the institutional level, and miscellaneous issues, such as working in-person, returning to work, or regarding funding agencies.

Table 5 Perceived barriers to decision-making

	All PIs		Assistant Prof.[A]	Associate Prof.[B]	Full Prof.[C]
	Count (%)	N	Count (%)	Count (%)	Count (%)
Personnel who had lack of childcare	453 (50)	912	72 (54)	129 (52)	220 (47)
Personnel at high-risk for complications from COVID-19	431 (47)	911	70 (52)	116 (47)	216 (46)
Institutional guidance that was too vague	382 (42)	911	67 (50)	106 (43)	188 (40)
Conflicting guidance from different levels within my institution	359 (39)	913	62 (46)	96 (39)	178 (38)
Lack of resources for protecting personnel who worked on-site[A.C]	**311 (34)**	**910**	**59 (44)**	**87 (35)**	**150 (32)**
Institutional guidance that was not relevant to my type of research	255 (28)	910	39 (29)	75 (30)	126 (27)
Lack of institutional guidance[A.B, A.C]	**229 (25)**	**911**	**57 (43)**	**59 (24)**	**101 (21)**
Institutional guidance did not give me enough discretion in my choices	217 (24)	913	33 (25)	56 (23)	118 (25)
Lack of institutional guidance regarding how to keep personnel safe[A.B, A.C]	**185 (20)**	**911**	**46 (34)**	**55 (22)**	**76 (16)**
Requirement that I communicate my decisions to my department chair	183 (20)	914	29 (22)	58 (23)	84 (18)
Tense interpersonal dynamics in my research group	170 (19)	911	29 (22)	51 (21)	75 (16)
Institutional guidance that was too specific	134 (15)	908	21 (16)	36 (15)	69 (15)
Institutional guidance gave me too much discretion in my choices[A.C]	**89 (10)**	**910**	**26 (19)**	**27 (11)**	**31 (7)**

PI principal investigator, *Prof.* professor

The academic rank variable compares Assistant, Associate, and Full Professors (n = 30 participants selected "other" in response to the rank item and are removed from these comparisons). The sample size for academic rank across items was as follows: Assistant Professors (n = 128–134), Associate Professors (n = 247–249), and Full Professors (n = 463–473)

Bold indicates that the chi-square test for the relationship of academic rank and the barrier was statistically significant (see narrative for results). All Bonferroni-adjusted post hoc z-tests for column proportions are statistically significant at $p < .05$ level. Superscripts indicate which groups differ (e.g., A.C = Assistant Professors differ from Full Professors.)

Barriers PIs encountered directly included their own childcare crises, doing more work themselves to reduce stress on their personnel, increased teaching burdens due to remote learning, disruption created by transitioning their work and/or the work of others in their living environment to function remotely, and clinicians having to stop research activities because of potential exposure. PIs wrote about concerns regarding the safety of people in the lab, isolation of trainees doing remote work, gauging staff members' actual hesitation or willingness to return to work in-person, and how best to balance the concerns and needs of different people under conditions of significant uncertainty. PIs also reported barriers related to peers who did not behave cooperatively to handle the shared challenges, ignored restrictions without consequences, or exerted pressure on their colleagues either to restart in-person or to continue to work from home.

Additional institutional barriers described by PIs included being afraid to voice opinions or make requests (e.g., asking for flexibility regarding a particular institutional policy) out of fear of reprimand, upper administration being slow to communicate and respond to PIs, lack of consistent definition and approval decisions related to "essential" research, conflict between institutional guidance and local guidelines, and frequent changes in policies and definitions.

With regard to in-person work or returning to the workplace, some PIs expressed concern about lack of testing and personal protective equipment (PPE). Others noted that some personnel or staff in other labs refused to wear PPE. Finally, not enough guidance and information from funding agencies, especially about what was allowable related to paying staff with grant funding, was noted as a barrier.

Perceived Facilitators to Decision-Making

The perceived facilitators among PIs are reported in descending order in Table 6. The average number of perceived facilitators was about 8 ($M = 8.24$, $SD = 3.45$, $n = 907$) out of 13 we presented in the checklist.

Only one item was perceived as a facilitator by fewer than 30% of PIs. Fifty percent or more of PIs perceived the remaining 12 items as facilitators. The most common facilitators pertained to social and interpersonal dynamics of the research team. PIs found it easier to make decisions when they had personnel who would voice their concerns and their team had positive interpersonal dynamics.

There was a significant relationship between rank and 8 facilitators: positive interpersonal dynamics, X^2 (2, $N = 849$) $= 11.65$, $p = 0.003$, personnel eligible to conduct on-site research, X^2 (2, $N = 851$) $= 8.97$, $p = 0.011$, feeling that institutional leaders trust them, X^2 (2, $N = 844$) $= 6.88$, $p = 0.032$, feeling supported by leaders or colleagues, X^2 (2, $N = 841$) $= 14.61$, $p < 0.001$, institutional guidance that was communicated quickly, X^2 (2, $N = 853$) $= 12.10$, $p = 0.002$, institutional guidance that was sufficiently detailed, X^2 (2, $N = 841$) $= 17.54$, $p < 0.001$, feeling they could talk to institutional leaders for help, X^2 (2, $N = 842$) $= 15.86$, $p < 0.001$, and feeling that administrators were handling the situation well, X^2 (2, $N = 843$) < 15.69, $p = 0.001$. A smaller proportion of assistant professors compared to full professors perceived all of these facilitators. A smaller proportion of associate professors compared with

Table 6 Perceived facilitators to decision-making

	All PIs		Assistant Prof.[A]	Associate Prof.[B]	Full Prof.[C]
	Count (%)	N	Count (%)	Count (%)	Count (%)
Research personnel who would speak up if they had concerns	824 (91)	902	117 (89)	226 (91)	436 (92)
Positive interpersonal dynamics in my research group[A.C, B.C]	**817 (91)**	**895**	**112 (86)**	**221 (89)**	**443 (94)**
Research personnel eligible to conduct on-site research according to institutional policy[A.C]	**785 (88)**	**897**	**106 (82)**	**213 (86)**	**427 (91)**
Having autonomy to make my own decisions	589 (66)	887	85 (66)	155 (63)	315 (68)
Feeling that my institutional leaders trust me to make good choices[A.C]	**577 (65)**	**890**	**73 (57)**	**157 (63)**	**319 (69)**
Feeling that I am supported by institutional leaders or colleagues[A.C]	**570 (64)**	**887**	**67 (52)**	**151 (61)**	**321 (69)**
Institutional guidance was communicated quickly[A.C]	**538 (61)**	**886**	**62 (48)**	**146 (59)**	**301 (65)**
Institutional guidance was sufficiently detailed[A.C, B.C]	**517 (58)**	**887**	**60 (47)**	**130 (52)**	**298 (64)**
Institutional guidance that gave me discretion in my choices	514 (58)	886	70 (55)	139 (56)	279 (60)
Feeling that I could talk to institutional leaders for help if I wanted[A.C]	**505 (57)**	**888**	**55 (43)**	**134 (54)**	**287 (62)**
Feeling that administrators at my institution were handling the situation well[A.B, A.C]	**502 (57)**	**887**	**53 (41)**	**137 (56)**	**283 (61)**
Trusting the administrators at my institution in general	475 (54)	885	59 (46)	127 (51)	262 (57)
Requirement that I communicate my decisions to my department chair	258 (29)	890	34 (27)	68 (27)	142 (30)

PI principal investigator, *Prof.* professor

The academic rank variable compares Assistant, Associate, and Full Professors (n = 30 participants selected "other" in response to the rank item and are removed from these comparisons). The sample size for academic rank across items was as follows: Assistant Professors (n = 128–134), Associate Professors (n = 247–249), and Full Professors (n = 463–473)

Bold indicates that the chi-square test for the relationship of academic rank and the facilitator was statistically significant (see narrative for results). All Bonferroni-adjusted post hoc z-tests for column proportions are statistically significant at $p < .05$ level. Superscripts indicate which groups differ (e.g., A.C = Assistant Professors differ from Full Professors.)

full professors reported positive dynamics in their group and sufficiently detailed guidance as facilitators. There were no gender differences for facilitators.

Open-Ended Facilitators Reported by PIs

Open-ended responses provided as additional facilitators were analyzed in the same manner as barriers (N = 155 PIs offered additional facilitators). Beyond facilitators from the checklist, PIs mentioned access to safety supplies, empty or available space to permit physical distancing while working in-person, funding flexibility or bridge funding, Zoom and other technological support, and personnel who were dependable and experienced as facilitating decisions and on-site or remote work. Many PIs felt flexibility in their research was beneficial, such as the ability to pivot to other areas of research or focus on work that could be done remotely. A number of individuals indicated that being senior and having tenure helped them because they felt that they could make their own decisions. PIs also reported it was easier to make decisions when they were certain that their research was essential, when they had support from peers at other institutions, and when there was open communication among PIs and resource sharing at their own institution.

The comments also revealed a distinction for some PIs between upper-level administrative communication at the institutional level, which was typically listed as a barrier, and college-level or department-level communication. PIs felt that good and frequent institutional communication, especially when decision-making happened at the college or department-level instead of at the top administrative level, helped them make decisions and get approval more efficiently.

PI Satisfaction with Their Decisions and Management of Personnel

Table 7 shows PIs' satisfaction with making decisions and managing personnel. Responses reflected a general sentiment that they did a good job overall, especially in ensuring personnel understood why they made the decisions they made and being fair. The lowest sense of PI satisfaction related to managing personnel who worked from home.

Findings from the personnel surveys indicate that these PI perceptions were largely accurate. Personnel views are generally congruent with PI views about decision-making at the onset of the COVID-19 pandemic. PIs were perceived by personnel as being fair and having done a good job of communicating with personnel about decisions that were made, yet there was some variability among personnel in their perceptions. We report on personnel satisfaction with PI decisions in greater detail in the supporting information (S1 Appendix).

There were differences by academic rank for nearly all items: feeling their research group understood their decisions, $F(2, 856) = 5.07$, $p = 0.006$, being satisfied with their decisions, $F(2, 857) = 6.92$, $p < 0.001$, being satisfied with their management of personnel on-site, $F(2, 856) = 8.97$, $p < 0.001$, feeling they did a good job responding to the COVID crisis, $F(2, 856) = 11.07$, $p < 0.001$, feeling confident in their decisions overall, $F(2, 859) = 6.97$, $p < 0.001$, and being satisfied with their

Table 7 Principal investigator satisfaction with their decisions and management of personnel

	All PIs			Assistant Prof.[A]			Associate Prof.[B]			Full Prof.[C]		
	M	SD	N	M	SD	N	M	SD	N	M	SD	N
I feel that the members of my research group understand why I made the decisions I made[A.C]	**6.09**	**0.86**	**901**	**5.91**	**1.03**	**132**	**6.03**	**0.93**	**251**	**6.16**	**0.77**	**476**
My decisions were fair to the members of my research group	6.07	0.85	901	5.95	0.92	133	6.05	0.84	251	6.11	0.84	475
I am satisfied with my decisions about conducting and staffing essential on-site research[A.C]	**5.93**	**1.02**	**902**	**5.66**	**1.14**	**133**	**5.87**	**1.03**	**251**	**6.02**	**0.98**	**476**
I am satisfied with how I managed personnel who did on-site research activities[A.C, B.C†]	**5.89**	**0.94**	**901**	**5.65**	**0.96**	**133**	**5.80**	**0.96**	**251**	**6.00**	**0.90**	**475**
I feel I did a good job responding to the COVID crisis as the PI of my research group[A.B, A.C]	**5.87**	**0.98**	**901**	**5.53**	**1.08**	**132**	**5.86**	**0.96**	**251**	**5.98**	**0.94**	**476**
Overall, I felt confident in my decisions about conducting and staffing research during the pandemic[A.C]	**5.47**	**1.46**	**930**	**5.06**	**1.62**	**134**	**5.41**	**1.47**	**251**	**5.59**	**1.41**	**477**
I am satisfied with how I managed research personnel working from home[A.B†, A.C]	**5.46**	**1.24**	**827**	**5.10**	**1.26**	**125**	**5.44**	**1.30**	**223**	**5.56**	**1.19**	**441**

PI principal investigator, *Prof.* professor, *M* mean (on a 1 [*strongly disagree*] to 7 [*strongly agree*] scale), *SD* standard deviation

The academic rank variable compares Assistant, Associate, and Full Professors (n = 30 participants selected "other" in response to the rank item and are removed from these comparisons)

Bold indicates that the omnibus ANOVA F-test for academic rank was statistically significant (see narrative for results). All Bonferroni-adjusted post hoc t-tests are statistically significant at the $p < .01$ level, except where noted. Superscripts indicate which groups differ (e.g., A.C = Assistant Professors differ from Full Professors.)

†Comparison $p < .05$

management of research personnel working from home, $F(2, 786) = 7.09$, $p < 0.001$. For each of these items, assistant professors had the lowest satisfaction. There was only one gender difference across these items. Women (n = 385) reported slightly lower confidence than men (n = 484) in their decisions about conducting and staffing research during the pandemic, $t(867) = 2.07$, $p = 0.039$; $M_{women} = 5.37$, SD = 1.56, $M_{men} = 5.57$, SD = 1.35). However, there was no longer a statistically significant difference after controlling for rank, $F(1,835) = 3.46$, $p = 0.063$.

Discussion

The majority of PIs in our sample prioritized the health, safety, well-being, and needs of their research team members when making decisions about staffing and conducting on-site research. By comparison, maintaining scientific productivity was of lesser importance. However, most PIs reported struggling with prioritizing various considerations and many experienced at least some symptoms of stress.

Although the well-being of research personnel was a top priority for all PIs, early-career PIs rated concerns about productivity, negative career impact, and risk to future research funding higher than their senior counterparts. This finding suggests that a multidimensional approach to institutional management of emergencies may be necessary, as faculty at different career stages may need different types and levels of support from their institutions to address unique struggles. Findings also indicate that PIs generally thought that they did a quality job of making decisions about staffing and conducting essential research at the onset of the COVID-19 pandemic.

Common barriers faced by PIs related to both limitations bearing on the lives of research personnel and limitations in institutional guidance provided to PIs. The most common barrier perceived by PIs was when personnel lacked childcare which affected who could conduct on-site research. Many PIs also noted their own childcare needs created major concerns. These real-world challenges regarding childcare, especially when exacerbated by unexpected emergencies, raise unresolved issues of fairness. To help offset these obstacles, PIs could consider making contingency plans for when team members' (or their own) capacity to work is limited due to personal life factors beyond their control. Such planning could include research project and activity triaging, identifying research tasks that can be done remotely or at flexible times, and having candid conversations with the team members about their personal and professional needs and constraints. These steps would support research team adaptability generally when "life happens," not only during a national or international crisis. Ideally, navigating such childcare considerations would not fall only to PIs where collective solutions are needed. At a minimum, PIs facing these challenges need support from their institutions, and the ability to be candid about their own needs and constraints. Study findings about the barriers PIs faced suggest the importance of institutional leaders considering professional and personal needs when developing guidance and deploying resources in emergencies.

A top facilitator for PIs was appropriate levels of institutional guidance and support. Guidance that is too vague, too specific, or contradictory can undermine PI decision-making. To best support PIs, institutions may need to take a balanced

approach to crafting and enforcing guidance when normal research operations are disrupted. This could include providing general principles or approaches for PIs to follow while also granting them autonomy in determining the specifics of implementing this general guidance in their labs. To support this decision-making, institutions could provide specific examples of how such guidance could be implemented (e.g., for a large vs. small lab or for different types of research) to help inform the decisions PIs make. This type of practical guidance could help mitigate researcher stress and help institutions achieve the goal of ensuring the safety and well-being of researchers. Regardless of guidance provided by the institution, the best results likely require some situation-specific flexibility and autonomy for PIs. Moreover, it may be most efficient to consider which guidance and decision-making during emergencies is most appropriate at the top level of administration versus at the college or departmental level. It is also essential that researchers, regardless of career stage, perceive and have equal access to guidance, support, and help from leaders.

Positive research team dynamics was a common facilitator for PIs. Positive team dynamics can take the form of psychological safety and openness in communication (Nembhard & Edmondson, 2006), appreciation for the hard work of others (Spreitzer et al., 2012), providing encouragement (Zhang & Bartol, 2010), and similar practices (Antes et al., 2019b; Antes et al., 2019c). Engaging in these practices can act as a buffer to the uncertainty and stress inherent to research (McIntosh et al., 2020), including situations when research operations change abruptly. As part of understanding the human impact of the COVID-19 crisis and planning for future research emergencies (Son et al., 2020), PIs will want to be mindful of leading their research teams with the aim of fostering positive team dynamics. To this end, institutions may want to consider implementing or enhance existing programs (e.g., training, coaching, and incentive/performance review systems) that educate, empower, and incentivize supportive leadership and mentoring practices among PIs. Likewise, PIs themselves need support and mentoring as much as ever, especially those earlier in their careers. In addition to institutional support, PIs can self-advocate and leverage their professional networks and relationships with peers to garner additional support. For instance, multiple PIs within a department could work together to pool resources, collectively problem-solve, and share strategies and advice as needs arise. Taken together, both top-down and bottom-up approaches are needed to support PI decision-making.

Despite PIs overall having perceived a greater number of facilitators than barriers, PIs earlier in their careers experienced barriers with greater frequency, and facilitators with lower frequency, compared to PIs later in their careers. PIs earlier in their careers also reported greater concern about the needs of people in their personal lives and following institutional policy, while at the same time perceiving less support from colleagues and institutional leaders. Women PIs reported greater stress than male PIs, and they weighed four priorities focused on the needs of personnel more heavily. These findings are consistent with other work that has revealed struggles among women and early-career researchers (Cui et al., 2021; Harrop et al., 2021; Kliment et al., 2021; Myers et al., 2020). Scholars have diverse needs and face unique constraints that are not experienced universally. Special consideration of the needs and barriers faced by scholars in these groups is warranted when institutional

leaders develop and implement guidance and policies for emergencies and for recovering from emergencies. Policies might even include tailored approaches to distributing resources and support during emergencies.

Limitations

The survey data collected have a number of limitations that should be noted. Data may be limited in the scope of views represented due to self-selection bias. PIs who felt positively about their decision-making or who felt strongly about the transition to essential research may have been more likely to participate. Furthermore, socially desirable responding may have shaped participant answers to survey questions, resulting in responses that tended toward more positivity or what might be socially desirable—such as indicating that the needs and safety of personnel were the highest priorities.

Our study was also cross-sectional in nature and does not account for changes in research operations over time as the COVID-19 pandemic has unfolded. Participants may have had responded differently if they had completed the survey at an earlier or later time point. Relatedly, many other national and global events co-occurred with the pandemic and the timing of this survey (e.g., national protests against systemic racism). It is unclear the extent to which these events shaped participation in our study or affected variables measured (e.g., stress).

We surveyed NSF- and NIH-funded PIs who had some on-site essential research that continued at the onset of the COVID-19 pandemic. Researchers and faculty who continued work in a fully remote capacity, in fields not funded by NSF and NIH, or who work in other types of roles (e.g., clinical or teaching-oriented roles) likely had difficulties and unique experiences that are important but were not the focus in this study. Moreover, certain fields and types of essential research (e.g., wet lab research) were more proportionately represented than other fields (e.g., social science research) in our sample; this is likely because certain types of research must be conducted in a lab on-site, whereas other research can be conducted remotely if needed. With social science research, there may have been increased concerns about posing additional risk to research participants or community members by asking them to participate in-person.

Another minor limitation is that our sample weighted toward tenured, full professors, although we had a large enough sample of assistant and associate professors to make meaningful comparisons. Our approach also did not allow us to obtain the perspective of highly junior researchers who had not yet obtained federal funding. Finally, 22% of respondents reported that some or all of their research performed on-site was related to COVID-19. We did not explore whether responses may have varied among this subgroup of participants, which could be explored in future analyses of these data. Overall, findings from this study do not necessarily generalize to the experiences of all researchers and faculty.

Our survey did not ask about specific childcare or family issues among PIs, or the health of participants or their families, which may have been salient and influential in their decision making. However, participants had the opportunity to add and

describe other considerations in open-ended responses. Other scholars were focusing on these other important topics (Del Boca et al., 2020; Sevilla & Smith, 2020; Shockley et al., 2021), so we chose to focus more centrally on decisions about continuing and staffing essential research.

Conclusion

In conclusion, PIs were forced to contend with myriad personal and professional tradeoffs when making decisions about staffing and conducting on-site research at the outset of the COVID-19 pandemic. These decisions were often made with limited or changing institutional guidance. Despite this reality, PIs generally felt they made the best decisions they could under the circumstances, but they did acknowledge that making these decisions was at least moderately distressing. Researchers earlier in their careers especially struggled, reporting greater difficulty and stress and lower satisfaction with their decisions. Women researchers also reported greater stress. Thus, our findings are somewhat encouraging but also sobering. There remain several concerns and barriers to decision-making likely to reappear in future emergencies when normal research operations must be suspended. The findings also suggest that concerns like productivity and career consequences may remain salient among early-career researchers. Both leaders of research teams and research institutions can leverage the findings from this study to understand the impact of the COVID-19 pandemic and inform the policies, practices, and resources that will be needed for future emergencies.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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