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Final Report

Assessing the Impact of COVID-19 on STEM (Science,Technology, Engineering, Mathematics) Researchers in India*

February, 2022

*This research is funded by DBT/Wellcome Trust India Alliance, led by Dr. Deepa Subramanyam, Scientist E, NCCS, and conducted by Monk Prayogshala

Table of Contents

Summary of Progress

Following is the research study's progress, commencing from 3rd May 2021 to 11th February 2022:

- **Literature review (Week 1 - Week 3) -** Literature search of past studies on relevant variables involving the impact of the pandemic on STEM researchers, suppliers of lab equipment, and funders.
- **Database development (Week 1 - present) -** This includes the relevant details (designation, contact, name) of the key stakeholders that can be contacted for participation in the project such as, heads of institutions (central government, state government, private, and deemed universities), funding agencies (government, private, and international) and suppliers of scientific materials and equipment.
- **Sign-up sheet (Week 2) -** This sheet was circulated on social media and STEM newsletters so that applicable individuals could sign-up to participate in the survey. It involved a brief description of the study along with an eligibility criteria for participation. There are over 250 sign-ups currently.
- **Survey development (Week 2 - Week 5) -** Questions for the survey were developed based on past literature relevant to the STEM field and inputs from subject matter experts. An attempt was made to include different aspects that were affected by the pandemic and in turn, had an impact on a researcher's scientific productivity. Quantitative as well as qualitative questions have been included in the survey for a richer understanding.
- **Interview Questionnaire development (Week 2 - Week 5) -** A structured interview questionnaire was developed for Early Career Researchers (ECRs), Heads of Institutes, Suppliers of scientific equipment, Funders/Donors, people who are thinking of leaving academia, and people who have quit academia. An in-depth interview of a few participants will provide ample information regarding the challenges faced by the scientific community due to the COVID-19 pandemic.
- **Institutional Review Board (IRB) (Week 3 - Week 9) -** The research protocol and materials (survey and interview questionnaire) were reviewed by members of the ethics committee. Various suggestions provided by the committee were incorporated into the study to ensure protection of rights and welfare of research participants. The study has been approved (IRB No. #065-021) by the Monk Prayogshala Institutional Review Board.
- **Translations and back translations for the survey (Week 8 - Week 11) -** The survey form will be made available in 10 different Indian languages (Hindi: 75, Marathi: 24, Tamil: 13,

Kannada: 6, Telugu: 1, Bengali: 18, Gujarati: 7, Malayalam: 11, Oriya: 3, and Assamese: 4) along with English (n = 912). Thus, the questions were translated and back-translated by a translation agency into the aforementioned languages. The interview on the other hand, would be conducted in 3 languages (namely, English, Hindi and Marathi) and was correspondingly translated.

- **Designing survey on Qualtrics (Week 5 - Week 13) -** Once the questions for the survey were finalised, the form was developed on Qualtrics for circulating the survey online. Various skip and display logic functions were used so that the questions based on different conditions were not presented to all the respondents. A separate survey form was designed for each language.
- **Incentive mechanism (Week 10) -** The participants will be provided with benefits of Rs. 100 and Rs. 1000 for participating in the survey and interview respectively at the end of the study. Along with that, a certificate of participation from India Alliance and Monk Prayogshala will be provided for taking part in the study. For this, preliminary designs of the certificate have been made and Amazon has been contacted for bulk voucher disbursal.
- **Survey Rollout (Week 13- Week 20) -** The Qualtrics form designed for the 10 regional languages along with the English survey was circulated to potential participants using multiple social media platforms.
- **Qualitative data collection (Week 13- Week 20) -** Semi-structured interviews were conducted online with the ECRs, Head of Institutions, Suppliers, Funders, and other stakeholders.
- **Data monitoring and validation (Week 21- Week 22) -** The data collected was cleaned for inconsistent and incomplete data to be included in the final analysis.
- **Quantitative and Qualitative Data analysis (Week 23- Week 26) -** The survey data was analysed both quantitatively through regression analysis (using R software), and qualitatively by computing sentiment and content analysis to answer each research question. The interview transcripts were thematically analysed using NVivo software for each stakeholder.
- **Report writing (Week 27- Week 28) -** The final report including all the details and results from the study was collated.
- **Dissemination (Week 29- Week 32) -** The executive summary, infographics, and the report of the project were finalised and disseminated.

Introduction

The COVID-19 pandemic has caused a dramatic loss of human life across the globe and presents unparalleled challenges to the world of work. Furthermore, the economic and social disruption caused by the pandemic is catastrophic (WHO, 2020). These effects have spread across all professions, and academics have not been immune to it. The challenges are exhibited in academic flexibility in terms of teaching, the need to teach courses online, using different platforms to interact with students and colleagues, and innovative ways to carry out research activities (Superfine, 2020).

Since March 2020, nationally mandated social distancing has led research institutes and universities to adhere to government guidelines in response to the pandemic (Termini & Traver, 2020). This resulted in unexpected roadblocks for academics with regards to permitted research operations, abiding to social distancing guidelines in the laboratory, facility closure, decreased laboratory activities and shifting to remote working (Termini & Traver, 2020). Further, early career researchers, including PhD students and postdoctoral fellows, have been affected at the most crucial time in their career development (Cheng & Song, 2020). Researchers have had to switch from working on their current research topic to focusing on COVID-19 based research and some others had to terminate or halt their research work altogether. All these changes have impacted the research, teaching and scientific productivity of academics.

Studies have explored how researchers in Science, Technology, Engineering, and Mathematics (STEM) fields have been coping with changes in routines, funding, among others in the wake of the pandemic, using international samples (Byrom, 2020; Myers et al., 2020). However, the few studies which have assessed the impact of the pandemic in India had a very narrow focus. While studies have considered gender as a variable, other factors pertinent to India such as caste, religion, economic background have thus far not been taken into account. Thus, the current study aims to understand a comprehensive effect of the COVID-19 pandemic on STEM research scientists and stakeholders (suppliers and funders) across India.

Objectives

The current study has the following broad-ranging objectives:

- To assess the extent of the impact (both positive and negative) of the pandemic on funding, research, teaching, and scientific productivity among researchers/academics in India.
- To understand the reasons and effects, if any, of the differential impact of the pandemic on STEM researchers based on socio-demographic factors like gender, caste, religion, economic background, to name a few.
- To understand the nature of social and institutional support received by various academics and/or researchers during the pandemic and if that had any effect on their research productivity.
- To understand if contracting the coronavirus by self/family/peer/relatives had an effect on the scientific productivity of researchers.
- To assess the impact of COVID-19 on mental health and well-being of researchers and academics.
- To understand the reasons behind and the effects of leaving/planning to leave academia due to the pandemic using a mixed methods approach.
- To qualitatively assess the effects of the pandemic among heads of institutes, suppliers, and funders.
- To outline policy recommendations that arise from various challenges faced by scientists and other academic stakeholders during the pandemic.

Literature Review

Primary research discipline and the effect of COVID-19

The COVID-19 pandemic affected researchers in different fields unevenly (Myers et al., 2020). Fields related to the bench sciences, that require physical laboratories, and rely on time-sensitive experiments, like biochemistry, biological sciences, chemistry, and chemical engineering had large declines in research time as compared to pre-pandemic times. On the other hand, fields that require less equipment such as mathematics, statistics, computer science, and economics reported low levels of decline in research time (Myers et al., 2020).

Furthermore, Korbel and Stegle (2020) found that one to six months of research work had been lost due to the shutdown of laboratories and there was a notable difference between dry labs and wet labs. Researchers working in a wet lab reported higher effect of the pandemic on their work as compared to the dry lab researchers (Korbel & Stegle, 2020).

COVID-19 Effects on Teaching

Along with difficulties in conducting research online, there have been a multitude of challenges faced by academics in the domain of teaching. Some of the challenges with online teaching can be broadly categorised under accessibility, affordability, flexibility, learning pedagogy, life-long learning, and education policy (Murgatrotd, 2020, as cited in Pokhrel & Chhetri, 2021). Additionally, many countries lack reliable internet connection and access to digital sources required for online teaching as well as learning (Pokhrel & Chhetri, 2021), making online teaching extremely difficult for both teachers as well as students.

Researchers, working in STEM fields in Australia, reported increased challenges in student supervision due to the lack of face-to-face communications and those with teaching responsibilities had increased teaching workload due to online teaching thus, limiting their research capacity (EMCR Forum, 2020).

Importance of Digital Literacy

This widespread transition to remote working has also made it necessary for researchers to have a certain minimum level of digital literacy. Findings from Yazon et al.'s (2019) study revealed a strong association between faculty members' digital literacy and competence to their productivity in research. This suggests that an increase in understanding, finding, and using information on digital platforms is positively related to faculty members' ability to conduct, complete, present, and publish a research article.

In addition to the need for digital literacy among educators, the introduction of virtual laboratories for engineering education has involved the special training of educators to conduct lab classes. This transformation has been received well by both teachers and students (Kapilan et al., 2021).

Difficulty Conducting Research Online

The COVID-19 pandemic has changed the way in which we conduct research (Mitchell, 2021). Individuals who will be the most affected are those who lack digital literacy or access to different technologies and research tools required to conduct research online (Mitchell, 2021). Further, a lack of in-person communication and timeliness have led researchers to use online surveys and rating scales to conduct research (Man et al., 2021), reducing diversity in methodologies.

Clinical trials for stem cell research have been gravely impacted by the pandemic as peer review processes cannot be worked on without laboratory experiments. In addition, the productivity of stem cell researchers has taken a hit, especially those amidst a career transition (Kent et al., 2021).

Impact of COVID-19 on Early Career Researchers (ECRs)

Scientists at all stages of their careers are impacted by the pandemic; however, early career researchers are significantly vulnerable. There has been a significant impact of the pandemic on early career researchers (ECRs) in terms of research productivity, timeline of conducting experiments and research studies, insufficient funding, and connecting with different scientists (Termini & Traver, 2020). The consequences of these effects are especially severe among the ECRs because it is a crucial period for development and advancement of their career. COVID-19 restrictions have led to limitations in collaborative research, informal exchange of ideas, building a

community, and training offered by the traditional laboratory setting. Furthermore, researchers are having insufficient funding due to which they are unable to continue their research work and provide their scholarly contributions. For some researchers, time-sensitive experiments (e.g., involving frozen materials) or premature termination of experiments had a negative effect on their studies and also prevented submission of manuscripts due to extended timelines (Termini & Traver, 2020).

In many cases, open search in the job market has been put on hold, due to which ECRs are unable to progress in their careers. Additionally, postdocs who are nearing the end of their contract are having difficulty getting employed and thus, many of them are reportedly seeking employment in non-academic sectors (Termini & Traver, 2020). Most researchers argue that the pandemic has negatively impacted their career prospects (Woolston, 2020). However, another study noted that students made short-term academic changes that affected their affected graduation, but there were no serious changes to career plans (Forakis et al., 2020).

A study by Byrom (2020) found that three-fourths of the participants (doctoral students and early-career researchers (ECRs) from the UK) were experiencing a negative impact of the lockdown restrictions on their ability to collect data, discuss ideas and findings with colleagues, and disseminate their research findings. Other participants also mentioned that there was a negative impact on data analysis, writing, and working on grant or fellowship applications. Further, there was reduced or no access to the software required for their research work. This decreased ability to work led to stress and worry about researchers' future plans resulting in low levels of mental well-being and mental distress. Additionally, it was found that researchers having lesser social support networks within and beyond academia tended to struggle with their mental well-being. Additionally, administrative burden undertaken by junior researchers due to remote work arrangements has contributed to pressure for early career researchers (Matthews, Álamo Rodriguez, Gray, 2021).

Among biodiversity researchers and conservationists in India, COVID-19 affected research, education, communication, networking, and on-field research activities. Specifically, the impact on ECRs was mainly related to different areas of research and education categories (Ramvilas et al., 2021).

Gender and Impact on Research Productivity during COVID-19

The stay-at-home orders, lockdowns, and school closures affected scientists, especially those who had to take care of children and elders (Myers et al., 2020; Kowal et al., 2020). STEMM (Science, Technology, Engineering, Mathematics, and Medicine) faculty had to manage their laboratory, transition to remote working, transfer courses to online platforms, continue to be academically productive and also, simultaneously take care of and home-school their children (Krukowski et al., 2021).

The notion that the lockdown has had a differential impact on men and women has received considerable recognition (Yildirim & Eslen-Ziya, 2020; Muric et al., 2021). Women academics have faced unequal work-life balance challenges during the pandemic leading to a reduction in the time spent on research hours as compared to men (Deryugina et al., 2021; Myers et al., 2020). In a dual-academic relationship, women are more likely to get lesser support at home than men (King & Frederickson, 2021). Research indicates that women have been significantly underrepresented in tenured- faculty positions (Snyder et al., 2019), particularly in STEM fields (Burrelli, 2008; Fox, 2001).

In general, productivity in academia is characterised by submitting grants and articles, publication success, as well as other activities, such as peer review and serving on funding panels, which are essential for promotion and tenure (Krukowski et al., 2021). A study by Krukowski et al. (2021) found significant changes in productivity before and during the pandemic suggesting that there were significantly fewer first/corresponding and co-authored articles submitted by women researchers. Further, there were significant decreases in productivity for individuals with children younger than the age of 6 years at home; however, on the other hand, individuals with children from the age of 6 to 18 at home reported significant increases or stable productivity.

Additionally, women's rate of productivity in last authorship positions has declined significantly, suggesting that women are being underrepresented in prestigious and all other authorship positions, leading to an increasing inequality during the pandemic. Further, the study also found a significant reduction in women authorships in the first, middle, last, and sole author positions in case of the arXiv repository which covers preprints in the fields of physics, maths, statistics, biology, to name a few (King & Frederickson, 2021). It was also noted that the daily routine of women academics due

to having children was disproportionately affected by the lockdown as compared to men. Thus, on account of the increased domestic burdens and the child care responsibilities during COVID-19 and their integrated impact on career productivity has been a threat to tenure and promotion of early career women researchers (Cardel et al., 2020).

Apart from gender, an ethnographic study in India had noted that Brahmins and other upper castes dominate in science, medicine, engineering, and academic professions and culturally shape institutions based on their caste identities (Thomas, 2020). In a survey conducted by NIH to understand the impact of the pandemic on scientists belonging to underrepresented racial and ethnic groups, participants reported a decrease in research productivity (NIH, 2020). A study of scientists in the USA revealed that male researchers without children were the least affected group in terms of productivity during the pandemic as compared to Black mothers, which were the most affected. It also mentions the presence of racism against black women in academia (Staniscuaski et al., 2021).

Institutional and Social Support Received

In a study conducted by Ogilvie et al. (2020) to understand graduate students' experiences during the pandemic, most of the respondents mentioned that they received more support from their advisors, professors, and peers rather than college or university administrators. Additionally, they also reported more support in terms of physical and mental well-being as compared to economic well-being (Ogilvie et al., 2020).

In developing countries like Bangladesh, it has been argued that institutional support during the pandemic is important to fill the academic gap that emerged due to the transition to a virtual education system (Ullah et al., 2021). Institutional support links various stakeholders to resources, expertise, and emotional support allowing navigation through the institution effectively and successfully (Ullah et al., 2021). Ullah et al. (2021) assess the amount of institutional support received in Bangladesh for online education during the pandemic. They found that even though a few universities provided average support for continuing online education, several problems like lack of software to conduct classes online, lack of training, lack of smartphones, poor internet access, etc. were noted.

Impact of COVID-19 on Mental Health of Academics

Researchers are facing high levels of stress (Shin & Jung, 2014, as cited in Camerlink et al., 2021) and uncertainty with regards to job position (Castellacci & Vinas-Bardolet, 2020, as cited in Camerlink et al., 2021) especially since the onset of the pandemic. It has been noted that researchers are facing additional mental health challenges and a reduction in life satisfaction due to the pandemic (Ammar et al., 2020, as cited in Camerlink et al., 2021).

The Australian Academy of Science, Early and Mid-career Researchers (EMCR) Forum conducted a national survey (2020) to understand the impact of COVID-19 on EMCR's in STEM fields in Australia. They found that the pandemic had a significant impact on mental health and productivity of scientists. Researchers perceived a loss of their career prospects and increased anxiety due to uncertain employment situations. Further, it was noted that female EMCRs with caring responsibilities, researchers who were early in their career, and researchers working on contract were the groups that were most impacted by the pandemic (EMCR Forum, 2020).

Impact of the Pandemic on Suppliers and Funders

In an interview conducted by Nature Communications (Matthews et al., 2021) , STEM researchers expressed several changes that have occurred in research funding for STEM and overall, in the scientific community. Many funding agencies have eased eligibility criteria in order to accommodate students that require funding. They acknowledge that while budget cuts may last longer than the pandemic, philanthropic donations may aid the situation of public universities (Matthews et al., 2021).

The operations and supply chain management have been influenced by the COVID-19 pandemic to a large extent (Lin et al., 2020 as cited in Queiroz et al., 2020). Disruptions to any of the global supply chains (e.g., manufacturers closed or partially closed, airports operating with harsh restrictions, shortages of medical equipment and supplies), can lead to the experience of ripple effects by many industries as well (Dolgui et al., 2018; Ivanov, 2020a, b, as cited in Queiroz et al., 2020). There has been an increase in demand for necessary items like personal protective equipment (PPE), ventilators, and canned foods because of the pandemic. However, due to the various

challenges faced by supply, transportation and manufacturing units, there has been a reduction in their capacities. The challenges faced by these units include border closures, lockdown in the markets, interruption in vehicle movement, suspension of international trade, labour shortage, and maintaining social distancing in manufacturing facilities (Paul & Chowdhury, 2020a; Amankwah-Amoah, 2020b, as cited in Chowdhury et al., 2021). This has substantially affected the suppliers ability to deliver products on time (Ivanov & Das, 2020, as cited in Chowdhury et al., 2021). Researchers across the world are facing difficulties with securing supplies like gloves, micropipettes, pipette tips, centrifuge tubes and other laboratory basics leading to an increased demand while the manufacturing and the distribution channels are disrupted (Woolston, 2021).

The world's major scientific funders have modified their funding policies in response to COVID-19 (Stoye, 2020). Horizon 2020, a European funding programme for research and innovation, provided researchers with extensions in their funding and also, allowed them to reallocate those funds to working remotely and paying salaries of researchers who could not continue with their experiments because of the lockdown. Further, reorientation of the projects to research on COVID-19 was also supported. Other funding institutions like Cancer Research UK, the Wellcome Trust, US National Institutes of Health (NIH), US National Science Foundation (NSF), and many more have provided maximum flexibility and relief to researchers impacted by the pandemic (Stoye, 2020). The NIH established the COVID-19 supplemental fund to assist affected researchers. They have extended the early-stage investigator status and have provided significant flexibility in terms of using the grant money (NIH, 2020).

Funding agencies in China, Italy, UK, and USA are providing no-cost grant extensions and extended grant deadlines (Colbert et al., 2020). The Canadian Institutes of Health Research (CIHR), a health research investment agency, also implemented the gender policy interventions during the COVID-19 funding competition that included extending deadlines and factoring sex/gender into the grant requirements. It was noticed that the CIHR received more applications and awarded a greater proportion of grants to female scientists as compared to male scientists along with that, many funded studies considered sex and gender in COVID-19 related research (Witteman et al., 2021).

Impact on STEM students (or those without a PhD degree)

A study by Gupta et al. (2021) reported that most US students' academic path was affected due to the pandemic and also creating a challenge to completing coursework for the degree requirements. Further, they mentioned having difficulty with regards to remote learning, displacement, and loss of opportunities. It was also noted that STEM majors showed concerns with regards to finding internship opportunities, quality of learning, academic performance, and being unprepared for on-site lab and advanced courses.

Another research from the United States reported that restrictions on access to resources and facilities along with delay in academic coursework led to a delay in graduation by doctoral, masters, and undergraduate students. Additionally, among those who delayed their graduation, Hispanic and Black undergraduates were more likely than Asians and Whites to delay graduation (Report 1; Saw et al., 2020). It was also observed that STEM female faculty and students reported facing more problems adapting to remote learning and technological issues as compared to their male colleagues and peers (Report 2; Saw et al, 2020). Furthermore, it was noted that PhD students in Brazil belonging to a minority ethnic group were more likely to be financially disadvantaged as compared to white students (Woolston, 2020).

Positive Outcomes of the Pandemic

Ranganathan et al.'s (2021) study on cancer care during the pandemic also highlighted the increase in value-based health care which involves focusing on a patient's outcome-based treatment wherein unnecessary tests are avoided and the provider is also monetarily compensated based on patient's health outcome; for example, initiatives such as 'Choosing Wisely' for cancer patients in addition to telephonic consultations. COVID-19 research has illustrated efficient ways of doing clinical cancer research that include less imaging which was learnt from large scale practice-defining trials resulting in modification of cancer trial protocols.

COVID-19 has also had a significant impact on scientific communication, collaboration, and training. Video conferencing has gained importance in terms of meetings, journal clubs, and communication with collaborators. In a study conducted among life science scientists, more than half of the participants suggested that their communication with mentors or supervisors had not changed and a few participants also noted an increase in communication. This suggests that video

conferencing has been effective in communication and mentoring during the pandemic (Korbel & Stegle, 2020).

It was also noted in the study that e-conferencing among life science scientists is becoming an important format for scientific meetings. During the lockdown, the adoption of e-learning software by life science trainees based in wet labs has increased. The trainees wanted to expand their skill set such as learning new programming languages. Particularly among life science trainees based in wet labs, the use of e-learning software during the lockdown to expand their skills (e.g., learning new programming language) has increased (Korbel & Stegle, 2020). Further, scientists noted that they spent more time in data analysis, manuscript or thesis writing, and developing grant applications. Some scientists also indicated shifting their research activities to contribute to COVID-19 related research (Korbel & Stegle, 2020). In sum, even though the pandemic had substantial effects associated with stress and work interruptions among scientists, new ways to cooperate, exchange ideas, and learn via electronic means were some of the positive impacts of the pandemic (Korbel & Stegle, 2020).

Vast literature has emphasised the scope of the impact of COVID-19 pandemic on STEM researchers all over the world. In particular, the pandemic has had a significant impact on ECRs, who are facing a barrier in the progression of their career, as well as women scientists who are unable to work to their full potential due to household or childcare responsibilities. Not many of these studies have focused on the pandemic's influence on Indian scientists. Therefore, the current study aims to understand the effect of gender, caste, childcare responsibilities, primary research discipline, transition to online working/ teaching, contracting COVID-19, funding opportunities, and institutional and social support received on scientific productivity, mental health and future career prospects among researchers in India.

Research Questions

In the context of emerging strands of literature on the impact of COVID-19 on STEM research, the current study posits the following research questions in the Indian context:

RQ1: What impacts the ability to continue one's research during the COVID-19 pandemic?
RQ2: What impacts one's ability to continue to teach during the COVID-19 pandemic?

RQ3: What impacts researcher's scientific productivity during the COVID-19 pandemic?

RQ4: What impacts mental health among STEM scientists during the COVID-19 pandemic?

RQ5: What has an impact on a STEM scientist's decision to return to academia, who left academia during the COVID-19 pandemic?

RQ6: What has an impact on a STEM scientist's plan to continue a career in STEM even if they are thinking about leaving academia?

RQ7: What was the differential impact of the pandemic among ECR's, Heads of Institutes, Suppliers and Funders?

RQ8: What are some of the reasons behind planning to leave academia?

RQ9: What are the reasons and effects of leaving academia?

RQ10: Are there any actionable policy recommendations that arise from various challenges faced by scientists during the pandemic?

Methodology

Aim

The aim of the study is to understand the comprehensive impact of the COVID-19 pandemic on STEM researchers and stakeholders (funders, institutional leaders and suppliers) across India.

Design

Employing a mixed method design, the current research study used both quantitative (survey) and qualitative (interview) methods to collect data from ECRs, Heads of Institute, suppliers, and funders. To make the survey more accessible to participants, it was made available in ten Indian languages (Hindi: 75, Marathi: 24, Tamil: 13, Kannada: 6, Telugu: 1, Bengali: 18, Gujarati: 7, Malayalam: 11, Oriya: 3, and Assamese: 4) along with English (n = 912).

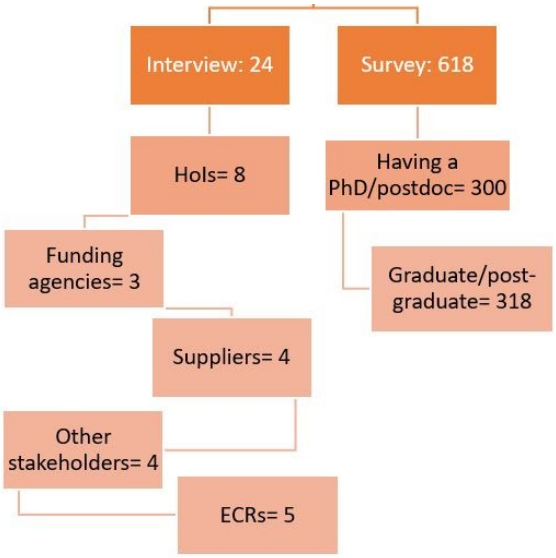
Participants

Participants were recruited via targeted emails to Institute/Department heads, networks of India Alliance, and snowball sampling using social media campaigns. The current study included participants from India who were 18 years and above, studying or working in a STEM-related field. The participants were early career STEM researchers (within 10 years of receiving PhD), senior postdoctoral fellows, researchers with their own labs/groups with less than 10 years of research experience, and those having a graduate/postgraduate degree. For the interview, heads of institutes, suppliers of scientific materials, and funders/donors, were included. The latter categories were recruited based on contacts provided by Dr. Subramanyam and India Alliance, as well as via a comprehensive database of Central Institutes in India.

A total of 1074 participants took part in the online survey. In-depth interviews of 24 stakeholders were conducted, which includes a subsample of heads of institutes (8), representatives from funding agencies (3), suppliers of scientific equipment and materials (4), other stakeholders (4) and 5 ECRs who elaborated on their reasons for planning to leave academia. Due to the unavailability and non-response from the funding agencies and suppliers of scientific equipment, it was decided that 4 other stakeholders would be interviewed and their responses are presented as individual case studies. The study was conducted to obtain representation from all regions of India and from researchers working in government research laboratories, universities, private institutes, and colleges.

Figure 1

Final sample size (N = 1074)



Measures (refer to Appendix A)

Survey

The survey form was designed and circulated online via Qualtrics. It included questions related to participant's socio-demographics, the effects of COVID-19 on research, funding, scientific productivity, teaching, institutional/social support, mental health, and details on COVID-19 information. Further, the survey also included questions for researchers who have left/are thinking of leaving academia.

Interview

These were scheduled with the heads of institutes, suppliers of scientific materials, funders/donors, ECRs, people who were thinking about leaving academia, and those who had already left academia based on mutual convenience. All interviews were audio-recorded for transcription at a later stage and were conducted using the Zoom video-conferencing software.

Procedure

The survey form included quantitative as well as a few qualitative questions. After consenting to participate in the study, the participants were asked a few demographic details about themselves. Next, they were asked questions regarding COVID-19 effects on their research, teaching, scientific

productivity, mental health, funding, institutional/social support, and details about COVID-19. One section of the survey was for researchers/academicians who were thinking of leaving academia or had left academia during the pandemic, to understand their reasons behind such a decision. Finally, the participants were debriefed about the study and were provided with the option of entering their email ID to receive a compensation of INR 100 and a certificate of participation from India Alliance and Monk Prayogshala for taking part in the study.

In-depth interviews were conducted with heads of institutes, ECRs (who were thinking about leaving academia, and those who had already left academia), suppliers of scientific equipment, funders/donors, and other stakeholders. Each participant was presented with the informed consent form before beginning the semi-structured interview. At the end of the interview, participants were debriefed about the study and were provided with a compensation of INR 1000 and a certificate of participation from India Alliance and Monk Prayogshala for taking part in the study.

Quantitative Results

RStudio software version 1.4.1717 was used for quantitative data analysis (RStudio team, 2021). From a total of 1074 responses, the data were initially cleaned for non-numeric and inconsistent values. Next, the dataset was divided into two groups, one for those who have completed their doctoral or postdoctoral training (N = 300) and another for those who have either completed their post-graduation or graduation (N = 318).

Participants having a doctoral or a postdoctoral degree

Descriptive statistics (see Appendix B, Tables 1 & 2)

The dataset included a total of 150 men, and 141 women having a mean age of 39.43 years (SD = 7.46). Out of the total number of participants, 162 individuals had a doctorate (MD or PhD) degree and 138 individuals had completed their postdoctoral training. Additionally, 149 of the total participants belonged to a dominant caste group (Brahmin, Kshatriya, Vaishya, and other upper castes) whereas, 36 participants belonged to an oppressed caste group (Scheduled Caste, Scheduled Tribe, Other Backward Class, and other lower castes). These are described in Figures 2a to 2c.

Reliability and validity

Indices for variables like digital literacy, core research issues, university support, social support, and mental health were developed. Cronbach's alpha and Confirmatory Factor Analysis using the MLR (Robust Maximum Likelihood) method of estimation was computed in order to evaluate the psychometric properties of the indices. Additionally, since the digital literacy, core research issues, and social support indices were found to be non-normal (see Table 3, Appendix B), a DWLS (Diagonally Weighted Least Squares) method of estimation was also computed to assess index validity. For the factor models, fit was measured by evaluating the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean Square Residual (SRMR), in order to determine optimal fit (see Table 4, Appendix B). According to the widely used criteria, a cut-off value $\geq$0.95 for CFI and TLI, $\leq$0.06 for RMSEA, and $\leq$0.08 for SRMR indicate a good model fit (Hu & Bentler, 1999).

Figure 2a

Gender distribution

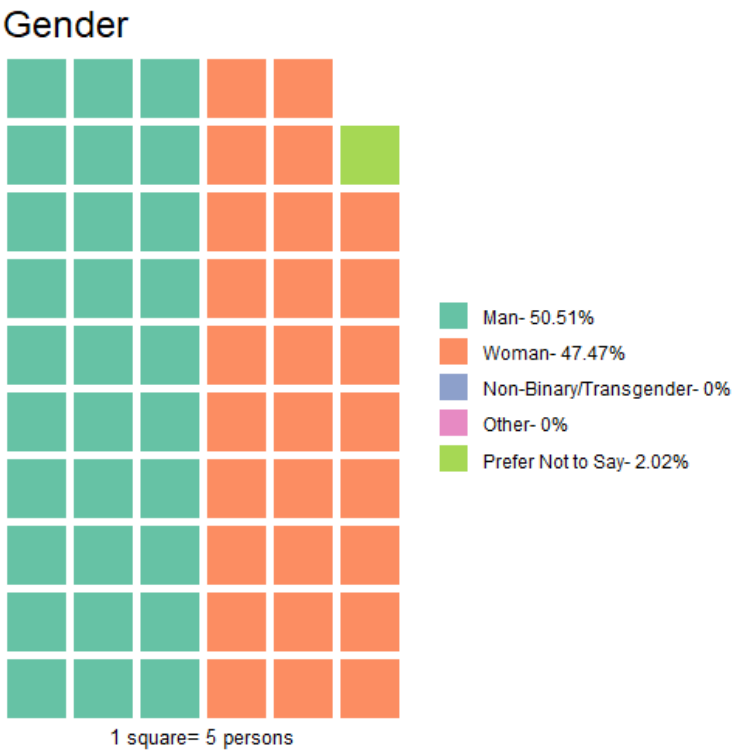
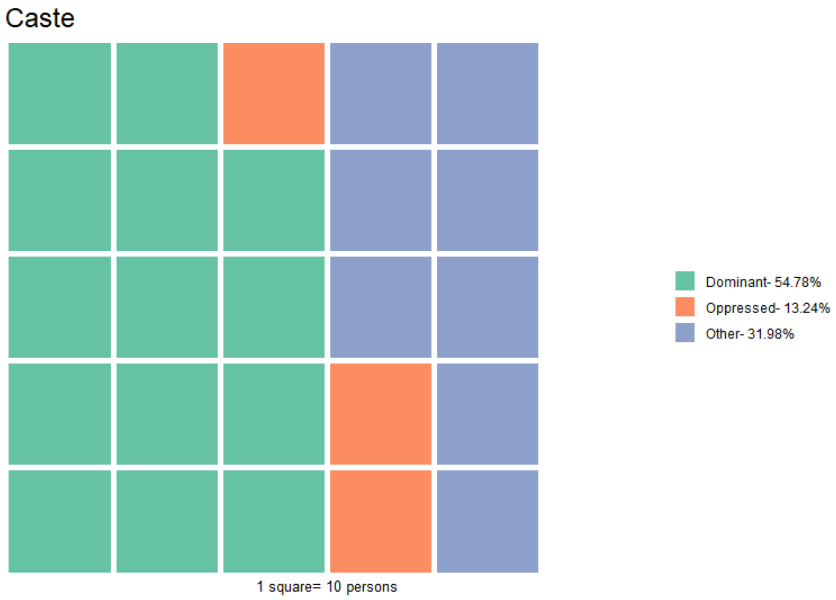


Figure 2b

Religion and caste distribution



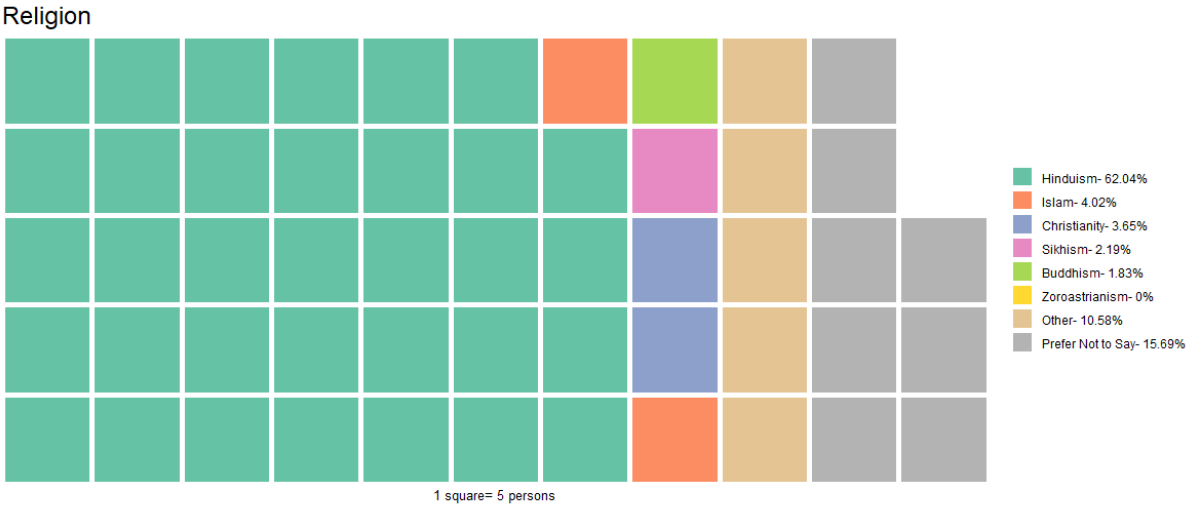


Figure 2c

Current position held and nature of position

Figure 2d

Funding Status

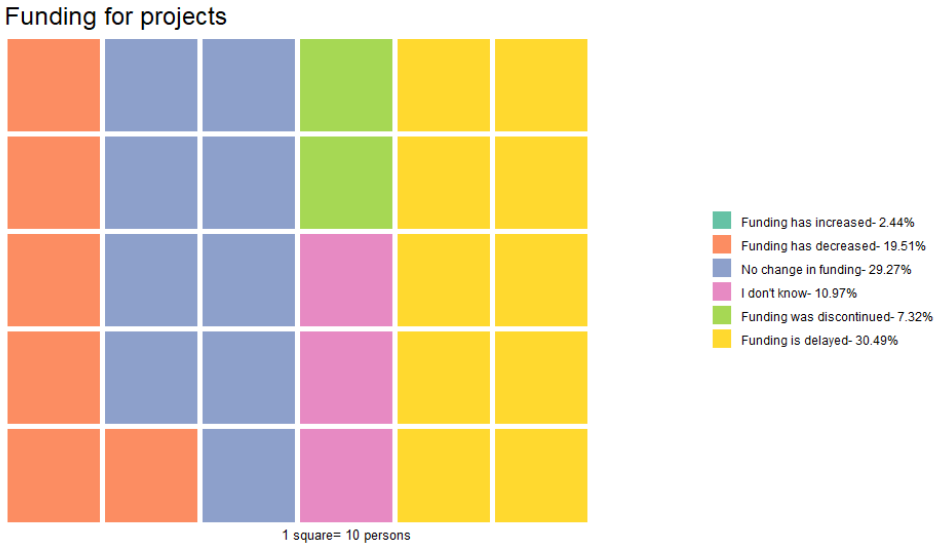
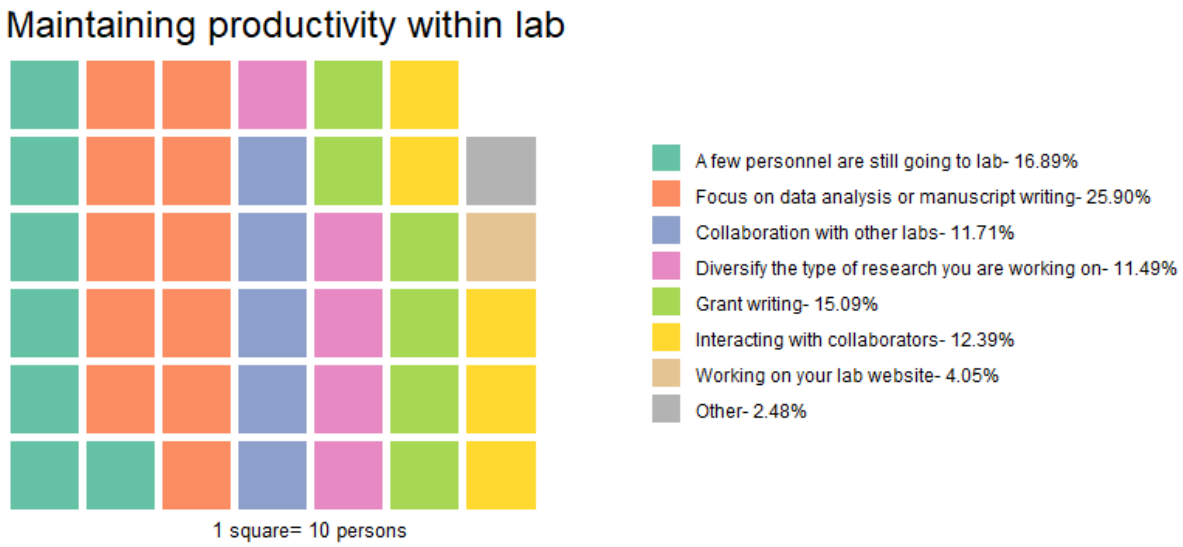


Figure 2e

Ability to maintain productivity in the lab



For the dataset involving individuals who had completed their PhD or postdoctoral degree, it was noted that the digital literacy index ($\boldsymbol{\alpha}$ = 0.93), the core research issues index ($\boldsymbol{\alpha}$= 0.80), university support index (α = 0.84), social support index ($\boldsymbol{\alpha}$ = 0.72), and the mental health index ($\boldsymbol{\alpha}$ = 0.70,) had a good internal consistency reliability and an adequate model fit[1] (Groskurth et al., preprint).

[1] It has been noted that the different goodness-of-fit (GOF) indices (like CFI, RMSEA, SRMR) are highly susceptible to extraneous data and the analysis characteristics like number of indicators, number of response

The core research issues index involved items related to difficulty in discussing research with colleagues, difficulty in data collection, difficulty in dissemination, methodological challenges, lab staff being asked to leave, decrease in lab staff, staff leaving affecting performance, and staff unable to continue research work on campus. The digital literacy index measured the participants ability to access email, virtually access bank account, use digital technologies, video conferencing, online file sharing, and learning new technology without the help of a third party.

University support index included the extent of physical, mental, material, and economic support received from university professors and administrators. Furthermore, support received from the university in terms of resources, flexibility in work hours, training, monetary assistance, and financial guidance were also measured. Support received from family, relatives, and peers in terms of physical, mental, material, and economic well-being were included in the social support measure. Mental health index comprised items related to overall mental health, work-life balance, amount of stress and happiness one experienced.

Correlations

A Pearson's correlation coefficient was computed to understand the relationship between the variables. As can be seen from the correlation matrix[2] (see Table 5) age was significantly negatively related to receiving a PhD or a postdoctoral degree suggesting that as age increases, the year in which one received their degree decreased. Further, it was also noted that if the number of people residing in a household along with those below the age of 18 years increased, one's access to independent workspace reduced. Additionally, a negative impact on teaching was positively correlated to difficulty in migrating to online teaching.

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options, and sample size, to name a few (Groskurth et al., preprint). Thus, the model indices should be interpreted with caution.

[2] Interpreting the correlation matrix: A positive correlation indicates a direct relationship between the variables (If X increases/decreases Y increases/decreases) whereas, a negative correlation indicates an inverse relation between the variables (If X increases Y decreases and vice versa). Additionally, a correlation closer to '1' (positive or negative) denotes a strong relationship among the variables and that closer to '0' shows a weak relationship. Finally, '*' signifies a statistically significant correlation between the two variables.

To further summarize the findings, greater social support was correlated with lower core research issues, a decrease in impact on supervisory role, and a decrease of negative impact on teaching. On the other hand, decrease in university support is related to an increase in disruption of lab supplies, core research issues, delay in PhD degree, delay in postdoc degree, disruption in receiving a grant or fellowship, personal financial instability, and impact supervisory role. In terms of scientific productivity, an adverse change in productivity was related to an increased reliance on a lab to conduct research, dependency on interaction with human participants, disruption in lab supplies, core research issues, and a lower university support.

Finally, better mental health was correlated with increase in access to an independent workspace, better stable internet connection, and greater social and university support. Additionally, better mental health was also related to decrease in disruption of lab supplies, difficulty receiving a grant, personal financial insecurity, change in productivity, impact on supervisory role, difficulty of migrating to online teaching, and a reduction in students' PhD degrees delay and postdoctoral scholars' training delay.

Table 5

Correlation matrix

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. Age										
2. Receive PhD/postdoc degree	-.83**									
3. People residing in household	-0.06	-0.03								
4. People residing in household below 18yrs	0.01	-0.03	.43**							
5. People residing in household above 60yrs	-.13*	0.05	.45**	.20**						
6. Caregivers in household	-.19**	0.09	.21**	.20**	.25**					
7. Access to independent workspace	0.08	-0.01	-.14*	-.15*	-0.02	0.08				
8. Depend on lab	-0.05	.17*	0.09	-0.01	-0.01	0.01	-0.06			
9. Human participants	0.09	-0.1	0	0.08	-0.03	-0.05	-0.01	.22**		
10. Remote working	.14*	-0.09	-0.04	-0.07	0.02	-0.09	.34**	-.29**	-.13*	
11. Stable internet connection	0	0.01	-0.07	-0.02	0.02	0.07	.44**	-0.06	-0.01	.35**
12. Disruption in supplies	0.04	0.08	0	-0.01	-0.06	0.01	-.17*	.57**	0.11	-.30**
13. Core research issues-total	0.07	-0.02	-0.01	-0.01	-0.12	0.04	-.28**	.30**	0.1	-0.1
14. PhD degree delay	-0.02	0.08	-0.11	0.01	-.19*	-0.01	-.19*	0.09	-0.08	-0.14
15. Postdoc training delay	-0.12	.19*	-0.05	-0.01	-0.09	0.05	-.29**	0.15	0.02	-.19*
16. Administration time	0.11	-0.12	0.05	0.01	-0.1	-.18*	-0.01	0.02	0.01	.18*
17. Professional development	-0.01	0.01	0.13	-0.09	0.06	-0.03	0.01	-0.03	-.16*	0.15

18. Digital literacy-total	0	-0.05	-0.06	-.19*	-0.04	-0.01	.16*	0.08	0.05	0.06
19. Difficulty receiving grant	-0.1	0.06	-0.04	0.05	0.03	0.07	-0.06	0.08	-0.06	0.11
20. Personal financial stability	-.17*	.18*	.17*	0.15	0.09	-0.03	-.29**	.16*	0.15	-0.1
21. Household financial stability	-0.1	0.14	.19*	0.1	0.06	-0.01	-.22**	.16*	0.1	-0.06
22. Scientific productivity	-0.01	0.14	0.04	0.02	0.04	0.05	-0.04	.31**	.21**	0
23. Impact on supervisory role	0.09	0	-0.13	-0.03	-.23*	0.07	-.28**	-0.03	0.13	-.27*
24. Migration to online teaching	0.06	-0.09	-0.1	-0.02	-0.08	0.07	-0.17	-0.06	0.09	-0.01
25. Negative impact on teaching	0.09	-0.05	0.05	0.03	-0.04	0.13	-0.08	-0.01	0.03	0.03
26. University support-total	0.03	-0.15	0.09	0.05	0.04	0.12	0.1	-.19*	-0.02	.20*
27. Social support-total	-0.03	-0.01	-0.07	-0.09	0.03	0.03	.36**	0.06	-0.08	0.1
28. Mental health-total	0.04	-0.09	0.01	0.06	-0.05	0.05	.30**	-0.07	-0.14	0.14

Variable	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
11. Stable internet connection										
12. Disruption in supplies	-.19**									
13. Core research issues-total	-.23**	.40**								
14. PhD degree delay	-.18*	.21**	.32**							
15. Postdoc training delay	-0.13	.25**	.40**	.68**						
16. Administration time	0.08	0.06	0	-0.02	-0.05					
17. Professional development	0.06	-0.05	-0.05	-0.03	0.05	.48**				
18. Digital literacy-total	.33**	0	-0.13	-0.02	-0.04	.22**	.17*			

19. Difficulty receiving grant	-0.06	.29**	0.12	0.05	0.08	0.01	-0.03	-.18*		
20. Personal financial stability	-.30**	.26**	.19*	0.05	0.13	-0.04	-0.02	-.22**	.26**	
21. Household financial stability	-.37**	.26**	.21**	0.02	0.13	-0.02	0	-.23**	0.15	.83**
22. Scientific productivity	-0.08	.32**	.36**	0.17	.25**	0.12	.20**	0.07	.21*	.29**
23. Impact on supervisory role	-.30**	.34**	.46**	.46**	.36**	-0.1	-.24*	-0.08	-0.02	0.12
24. Migration to online teaching	-.20*	0	0.04	.33**	0.11	-0.03	-0.07	0	-0.01	0.04
25. Negative impact on teaching	-0.17	0.07	.26**	.30**	.23*	0.08	-0.01	-0.08	0.01	0.08
26. University support-total	.27**	-.20*	-.20*	-.25**	-.23*	.18*	-0.02	-0.05	-.30**	-.24**
27. Social support-total	.22**	-0.11	-.29**	-0.08	-0.15	0.11	0.14	.18*	-0.04	-.18*
28. Mental health-total	.24**	-.20*	-.34**	-.30**	-.29**	-0.01	0.03	0.11	-.29**	-.26**

Variable	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*
21. Household financial stability								
22. Scientific productivity	.23**							
23. Impact on supervisory role	0.12	0.19						
24. Migration to online teaching	0.12	0.05	.46**					
25. Negative impact on teaching	0.12	0.13	.57**	.47**				
26. University support-total	-0.15	-.19*	-.30**	-0.07	-0.04			
27. Social support-total	-.19*	-0.04	-.29**	-0.18	-.20*	.31**		
28. Mental health-total	-0.16	-.34**	-.37**	-.22*	-0.11	.41**	.41**	

Note. * p < .05. ** p < .01.

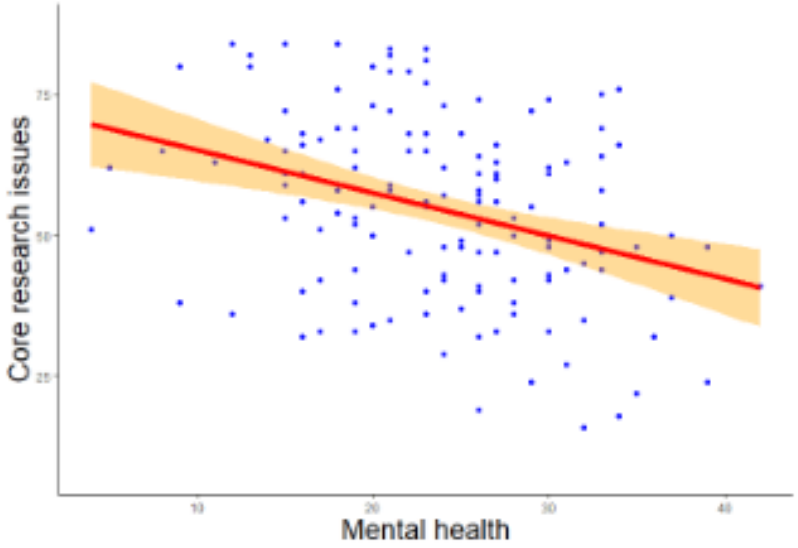
Regression analysis

Based on significant correlations between variables, multiple regression models were computed using pairwise deletion (lavaan; Rosseel, 2012) to answer each above-mentioned research question (see Table 6). Additionally, regression analysis was also performed on disaggregated datasets based on gender (males and females) and caste (dominant and oppressed caste). Additionally, a post hoc power analysis using G*Power (Faul et al., 2009) was computed for all the models having at least one significant predictor. It was observed that the models had a high power ranging from 0.95- 1.00 (α = 0.05) for the differing effect size, sample size, and number of predictors for each model. Regression results allow us to examine specific hypotheses related to certain variables, while controlling for other confounding variables. In this way, the results focus on the statistically significant (or otherwise) association or effect between the explanatory variable and the outcome(s) of interest.

The results (Figure 3) showed that lower mental health significantly predicted a greater number of core research issues (β = -0.546, z =-2.807 , p = 0.005), greater difficulty in receiving a grant, significantly predicted a greater disruption in lab supplies (β = 0.18, z = 2.345, p = 0.019), and a higher digital literacy significantly predicted an increase in the number of working hours in terms of professional development (β = 0.034, z = 1.959, p = 0.050). This suggests that mental health, difficulty receiving a grant, and digital literacy had a significant impact on one's ability to continue one's research during the COVID-19 pandemic (RQ1).

Figure 3

Regression analysis of mental health on core research issues



It was observed (Figure 4a) that greater disruption in procuring lab supplies had a significantly higher impact on an individual's supervisory role (β = 0.254, z = 2.051, p = 0.040) thus affecting one's ability to continue to teach during the COVID-19 pandemic (RQ2). Note that no statistically significant relationship was observed between disruption in lab supply and other aspects of online teaching (e.g., migration to online teaching). Further, greater core research issues predicted an adverse change in researcher's scientific productivity during the pandemic (β = 0.024, z = 2.136, p = 0.033; RQ3). Finally, it was noted that STEM scientists' better mental health (RQ4) was significantly predicted by a lesser difficulty in receiving a grant (β = -0.343, z = -2.302, p = 0.021, Figure 4b), a smaller change in scientific productivity (β = -0.707, z = -2.602, p = 0.009), higher university support (β = 0.069, z = 2.070, p = 0.038, Figure 4c), and higher social support (β = 0.189, z = 3.963, p = 0.00).

Figure 4a

Regression analysis for men and women of lab supplies disruption on supervisory role

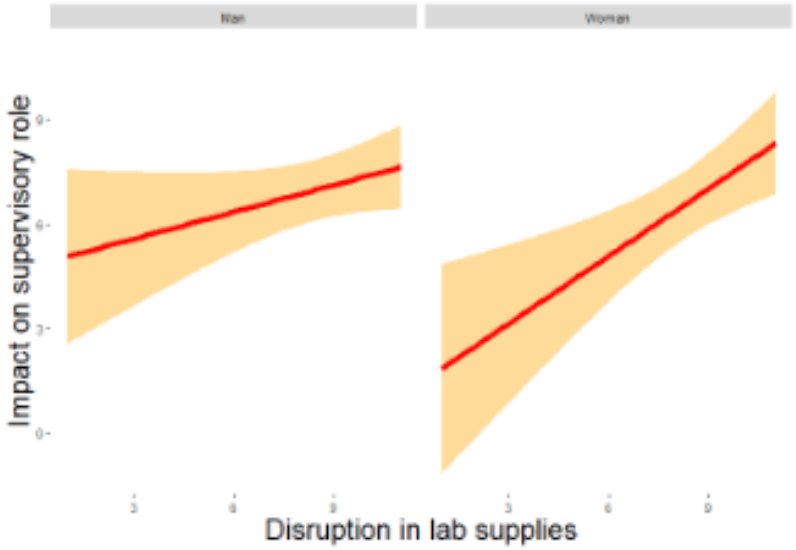


Figure 4b

Regression analysis of difficulty of receiving a grant and mental health

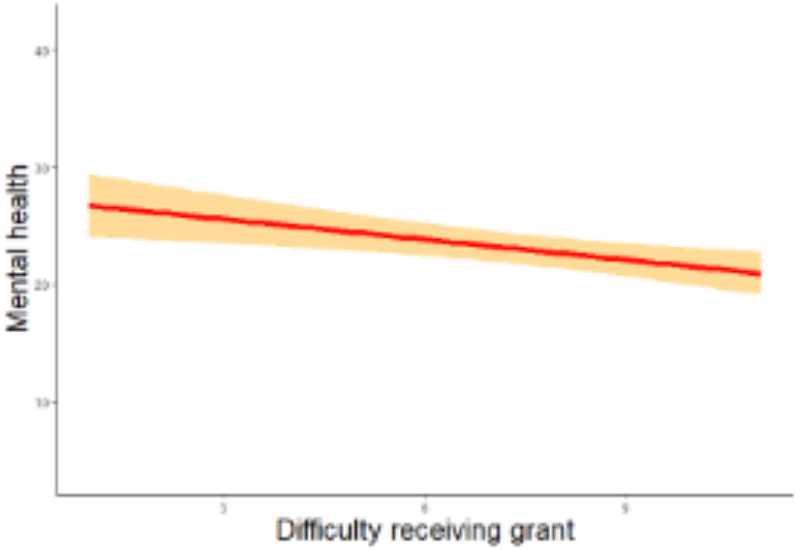
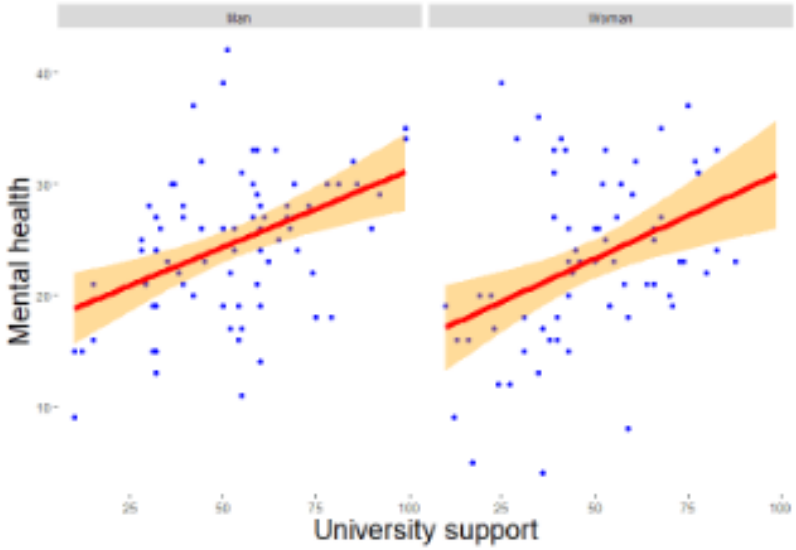


Figure 4c

Regression analysis for men and women of university support on mental health



For men, it was found that greater core research issues were significantly predicted by lower mental health (β = -0.58, z = -2.152, p = 0.031), and higher the difficulty in receiving a grant predicted a greater disruption in procuring lab supplies (β = 0.252, z = 2.058, p = 0.040). This suggests that mental health and difficulty receiving a grant were major aspects affecting men's inability to continue research during the pandemic (RQ1). Furthermore, higher the research dependency on interactions with human participants (β = 0.175, z = 2.290, p = 0.022) and greater core research issues (β = 0.039, z = 2.406, p = 0.016) significantly predict adverse changes in scientific productivity for men (RQ3). Higher university support (β = 0.072, z = 2.151, p = 0.031) and social support (β = 0.127, z = 2.015, p = 0.044) predicted a better mental health among men (RQ4).

For women, on the other hand, it was noted that lower mental health significantly predicted higher core research issues (β = -0.547, z = -1.995, p = 0.046) thus, impacting their ability to continue research during the pandemic (RQ1). Additionally, a higher disruption in procuring lab supplies predicted a greater impact on their supervisory role for PhD students (β = 0.402, z = 2.126, p = 0.033), and a lower mental health predicted a greater the difficulty to migrate to online teaching (β = -0.091, z = -1.956, p = 0.050) consequently affecting female's ability to continue to teach (RQ2). Adverse change in scientific productivity (RQ3) was predicted by greater personal financial instability (β = 0.252, z = 2.850, p = 0.004) and lower mental health (β = -0.081, z = -2.042, p = 0.041). Greater difficulty receiving a grant (β = -0.531, z = -2.508, p = 0.012), adverse change in productivity

(β = -0.977, z = -2.929, p = 0.003), and lower social support (β = 0.220, z = 3.378, p = 0.001) significantly predicted lower mental health for women (RQ4).

For dominant castes, who form a majority in our sample, it was observed that being able to manage switching to remote working (β = -0.396, z = -2.876, p = 0.004), better stability in internet connection to work remotely (β = -0.387, z = -2.198, p = 0.028), and lesser disruption in lab supplies (β = 0.285, z = 2.057, p = 0.040) had a lower impact on one's supervisory role (RQ2). A better stability in internet connection to work remotely (β = -0.608, z = -3.888, p = 0.00) and a better mental health (β = -0.103, z = -2.069, p = 0.039) significantly predicted a lower difficulty to migrate to online teaching (RQ2). Further, a higher dependency of working in a physical lab predicted an adverse change in scientific productivity (RQ3; β = 0.242, z = 2.168, p = 0.030). It was also noted that a greater social support predicted better mental health (β = 0.179, z = 2.328, p = 0.020) among the dominant caste group (RQ4). Note that these are not relative to the oppressed caste group as there were insufficient data on oppressed caste group members in the survey.

Table 6

Multiple Regression Model estimates for each research question

Research Question	Full Sample		Men		Women		Dominant caste	
	N	R^2	*N*	R^2	*N*	R^2	*N*	R^2
RQ1- What impacts the ability to continue one's research during the COVID-19 pandemic?-Core research issues	233	0.158	117	0.27	113	0.083	127	0.158
RQ1- What impacts the ability to continue one's research during the COVID-19 pandemic?-Logistic issues (Disruption in supply)	248	0.15	122	0.18	122	0.134	135	0.147
RQ1- What impacts the ability to continue one's research during the COVID-	172	0.031	88	0.055	83	0.008	90	0.02

19 pandemic?-Peripheral issues (Professional development)								
RQ2- What impacts one's ability to continue to teach during the COVID-19 pandemic?- Impact on supervisory role	248	0.28	122	0.339	122	0.414	135	0.407
RQ2- What impacts one's ability to continue to teach during the COVID-19 pandemic?- Difficulty migrating to online teaching	245	0.069	120	0.094	121	0.068	123	0.271
RQ2- What impacts one's ability to continue to teach during the COVID-19 pandemic?-Negative impact on teaching	245	0.057	120	0.074	121	0.049	133	0.106
RQ3- What impacts researcher's scientific productivity during the COVID-19 pandemic?	248	0.274	122	0.352	122	0.276	135	0.304
RQ4- What impacts mental health among STEM scientists during the COVID-19 pandemic?	248	0.395	122	0.388	122	0.468	135	0.393

The oppressed caste group had a very small sample size (n = 36); hence, the correlations potentially show spurious relationships that might lead to inaccurate inferences and as a result, are not reported here. We discuss the implications of this in subsequent sections of the report.

For those who had left academia (RQ5; N = 23) or were thinking about leaving academia (RQ6; N= 24), due to a small sample size, statistically robust and reliable results were not obtained. Hence, qualitative data was used to gauge scientist's reasons for leaving or considering leaving academia. This is discussed in the following section.

Qualitative Results

Sentiment Analysis

Using the 'bing' dictionary within the 'dplyr' package in R Studio, we explored whether certain qualitative descriptive responses were positively or negatively coded. Specifically, certain emotionally-loaded words were examined and classified at the document level. First, each response for each question was unnested into unigrams (i.e., single words); these words were then assigned positive/negative scores. Next, we further listed the phrases in context using the "keyword in context" function in the "quanteda" package. This function returns words in the immediate context of provided keywords. The main results are summarised in Figure 5 below.

Methodological Challenges

We found that the overall sentiment regarding methodological issues were negative, with 73 negatively coded words, and 30 positively coded words. The keywords "method," "work," and "research" were provided; participants discussed "stopping" their own research work, "remote data collection," having to change their methods, and not being able to work.

Professional development

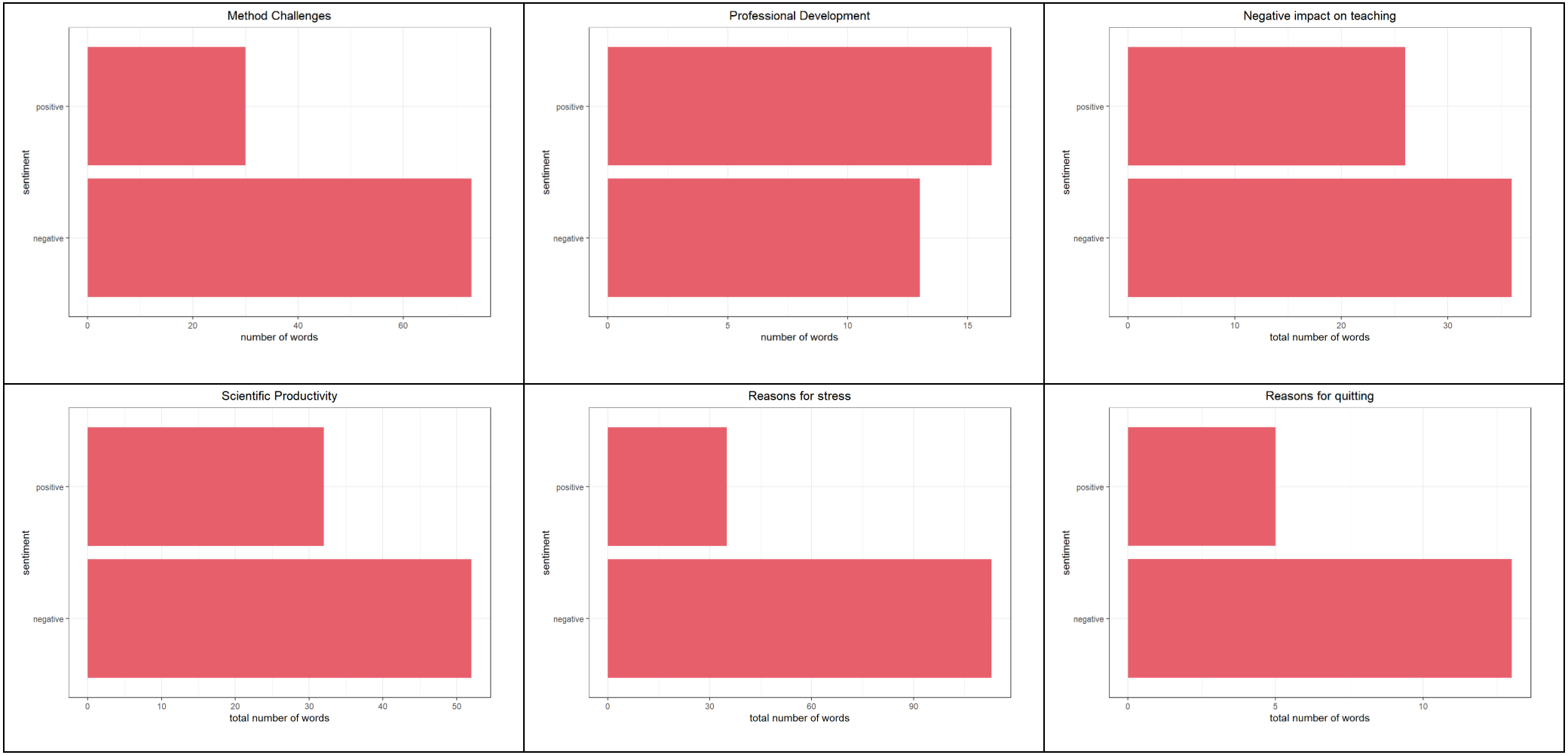
A total of 16 positive and 13 negative words were used to describe the changes in professional development. Using the keywords "profession," "develop," and "skill," we found that participants discussed having more time for professional development, and participating in programmes and workshops online.

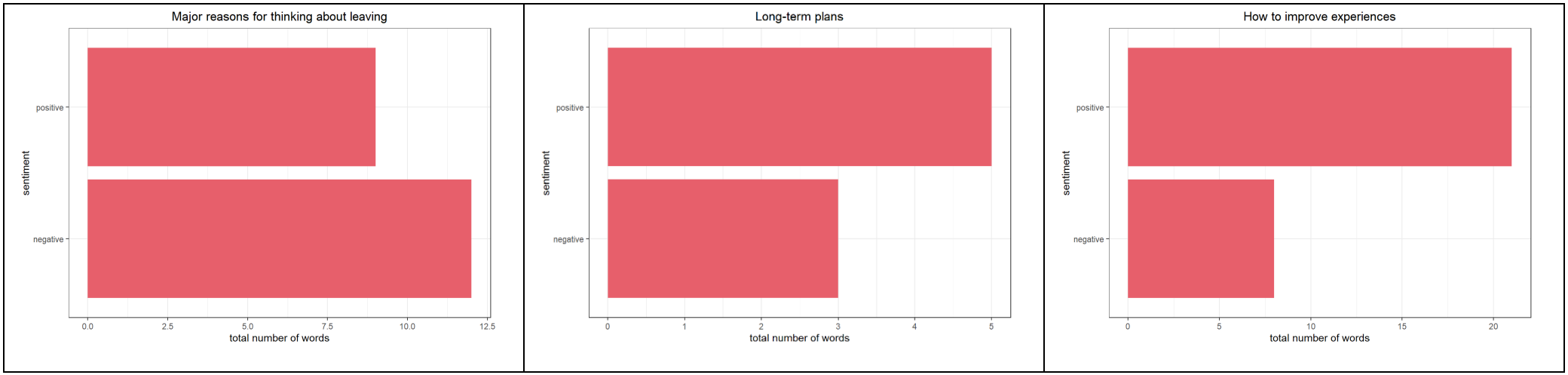
Impact on Teaching

To describe the negative effects of the pandemic on teaching, participants used 36 negatively coded terms and 26 positive ones. This included discussions about not being comfortable teaching online, lack of lab tutorials and practicals, and lack of feedback and engagement with students.

Figure 5

Sentiment analyses results





Note: Graphs summarise positive and negative sentiment frequencies of number of words used in a random 6% sample of all descriptive responses provided by survey participants.

Scientific productivity

Fifty-two negative words and 32 positive words were used to describe changes in scientific productivity. Participants discussed how there were personal and health based issues, as well as having spent time trying to keep the lab running, rather than on science. In other words, administrative duties and personal issues took away from being productive. On the other hand, once lockdown restrictions were lifted, participants reported being productive. Similarly, one participant discussed replanning experiments such that one person could run them.

Mental Health

To describe reasons for stress, 113 negative words and 35 positive words were used. Participants described a lack of social interaction, physical activities, being isolated, increase in workload, among other difficulties. The following keywords were used: "stress," "because," "anxious," "anxiety," "nerv," "deal," "mental," "health." This yielded responses describing helplessness, death anxiety, and stress related to financial and career trajectories.

Long-term plans

Five positive and three negative words were used to describe long-term plans after quitting. These include description of life as uncertain and requiring health and money; further, a few described wanting to switch to industry jobs, and general discontent with academia in India.

Reasons for leaving

Twelve negative words and nine positive words were used to describe reasons for leaving academia. Participants described a lack of money, an abundance of bureaucratic and administrative issues and duties. Further, the number of research positions reduced and salary delays were mentioned.

Recommendations

Participants used more positive than negative words when asked recommendations for improving academic experiences. These included transparency, growth opportunities, timely disbursements of funds, improving diversity, and other professional development opportunities.

Content Analysis

The findings from the sentiment analysis were then validated at the document level by the authors. For these findings, we randomly selected 38 responses (6.03%) from the 630 responses from the survey and analysed survey questions corresponding to the first four RQs of the study (detailed tables can be found in Appendix C). The responses were categorised based on themes that emerged from the data. The number of responses under each theme along with a few quotes[3] representative of the theme was added.

Among the methodological challenges faced by respondents (RQ1.A) while conducting research during the pandemic, key themes identified in the descriptive responses relate to money/funding (e.g., *"Slowing of fellowship disbursement from funding agencies and home institute."),* disruptions to wet lab work (*"Wetlab has been greatly hampered and so review work has been done more broadly."); *and lack of technical support *(e.g., "It was difficult to get technical support from the service people when instruments like genetic analysers don't work.")*.

Resources that impact the researchers ability to continue their research during the pandemic that are related to professional development (RQ1.B) include attending conferences and online workshops (e.g.*"I invested time in many online certificate courses")* while also the lack of time for professional development (e.g. *"There was no extra time for professional development, given the emergency need to develop online teaching material etc."*)

The factors that impact the researcher's ability to teach during the pandemic (RQ2), as elucidated by the respondents, include a decrease in attention spans (e.g.*"Response of students and interaction decreased a lot."*) and methodological challenges associated with online learning and teaching (e.g. *"I am an effective user of the 'chalk and talk' method of teaching. My skills associated with this method as well as those associated with interpersonal communication in face-to-face classes could not be applied much in online teaching."*)

The factors that affected the researchers scientific productivity during the pandemic (RQ3) include a lack of motivating and uncertainty (e.g. *"low motivation, uncertainty");* a loss of time due to the lockdown and the associated restrictions on movement that led to a lack of access to laboratories; a

[3] Please note that the quotes from the survey responses have been edited for clarity and grammar throughout the report.

decline in scientific output; mental health related challenges; a change in their field of research (e.g. *"I had to transition my research from Tuberculosis to COVID-19 for a while. It started as a transient gig but it has already consumed 6 months so far & I don't know when I'll be able to work back on tuberculosis research"*); however, a few respondents responded with additional time due to the lockdown that allowed them to work on other projects (e.g. *"I have used this time to write up old datasets and encouraged my students to work on secondary data (since they were unable to generate new data for their planned projects). This meant that I was actually writing more than I typically have time for."*)

From responses on the factors that impact the mental health of STEM scientists during the pandemic (RQ4), the themes that emerged were: family and household responsibilities (e.g.*" Since schools and daycares are not functioning my 3 years old kid is at home but I have to go to the office for my job. Fortunately, my husband has a work from home option so he is managing my kid. But still, he will be busy with online office meetings. So we are not able to spend time with the kid and not able to engage the kid."*); fear of losing their job and career-related stress (e.g. *"Financial instability and insecurity of the jobs."*); delays in funding (e.g. *"Secondly, delay in funding disbursement changed me personally especially during my COVID-19 infection."*); fear for their health and their family's well-being (e.g. *"Concern regarding health of parents"*) and fear of infection from COVID-19.

ECRs (participants who had completed their PhD/post doc) reported that the major reasons for leaving academia (RQ5) were: reduced funding/money (e.g. *"No pay for 6 months due to delays in grant release with no support from the institution to ensure the grant gets released."*), retirement, increased work pressure and workload (e.g. *"Too much work, too many research projects + online teaching, constantly on a computer with no time for personal work which started interfering with my health."*), child-care responsibility (e.g. *"Need for partial work-from-home options to balance childcare needs."*), and lack of opportunities (e.g. *"The pandemic also shut doors to various available research opportunities."*). Additionally, those ECR's who were thinking about leaving academia (RQ6) mentioned lack of funding (e.g. *"Reduced funding"*), poor work culture (e.g. *"Unfair professional assessment at workplace"*), issues related to salary/money (e.g. *"Not sure when salary for myself and the other research staff will be released"*), lack of support (e.g. *"Lack of support from upper management"*), higher work pressure and workload (e.g. *"A lot of pressure"*), bureaucratic issues (e.g. *"Unfair, hypocritical, opaque system."*), and lack of job stability/security (e.g. *"Lack of job stability"*) as reasons for the same. More details can be found in Appendix C (Table Group 1).

Survey respondents were asked, according to them, which group of people within their research institute had faced the maximum setback due to the pandemic. From the respondents who have a doctoral or postdoctoral degree (299 responses), ECRs were mentioned 86 times; doctoral researchers were mentioned 104 times; post-doctoral researchers were mentioned 10 times; the head of the institute once; faculty and employees had 9 mentions and other responses (10) included women professionals and those that worked in non-COVID-19 fields of research. More details can be found in Appendix C (Table Group 2).

Qualitative Interviews

Responses from the qualitative interviews conducted with the Heads of Institutes (8), funding agencies (3) and suppliers of scientific equipment (4). Extensive and detailed interviews were conducted with heads of institutes (8), representatives of funding agencies (3) and suppliers of scientific equipment (4) to determine their views on the impact of the pandemic on research and the functioning of their organization and employees.

Heads of Institute Responses

A. COVID-19 Effects on the Institute

1. *Impact of research within the institute since March 2020*

- In certain cases, equipment from the lab needed to be maintained, so special permission was sought from the government to conduct such maintenance under emergency operations. In one institute, the state of the art labs were converted to test for COVID-19 virus.
- Several students and faculty members were able to work from home because they focused on theoretical rather than practical aspects of their field of research. They were also able to communicate effectively with each other.
- Among those researchers who were focused on more lab based research, due to the government directions, their research pivoted towards COVID related research. Research in developing cost-effective methods of RT-PCR testing was done and developments related to masks were also made.
- Once the lockdown was lifted, with proper precautionary measures, a few scientists returned to their laboratories. Definitely, there was an impact on research during these months due

to restrictions, but with directives and measures such as shifts for researchers the impact on research was managed.

2. *Digital literacy training for the scientists/researchers*

- One HoI mentioned that due to their staff and scientists being highly qualified there was no need for any digital literacy training, and the staff and students could pick up any skill they required fairly easily. The only thing that was required when the lockdown was enforced and online classes began was to procure software meant for virtual learning.
- Another HoI mentioned that digital training was provided for the staff and the students along with the use of different software and learning platforms.

3. *Formal policies enforced/changed in response to the pandemic*

- One institute put together a plan for work from home for its staff and scientists which was lifted and enforced as and when lockdown restrictions were enforced. This system worked out well for the employees in terms of minimising the risk of infection and minimising the adverse impacts on their work. This also included the regular COVID-related protocols with respect to social distancing, masks, regular testing of personnel, regular supply of sanitisers and other COVID related equipment and emergency hospital arrangements in place. These also included arrangements to be made for any essential work related or emergency related deliveries to be made to the employees' residences.

4. *Challenges associated with the virtual mode of communication*

- There has been slight hesitation on the part of the faculty members in being able to virtually communicate among themselves on an interpersonal level due to the work from home situation. Scientists have been trying to manage both home and work responsibilities quite suddenly and that has been a challenge, shared one HoI.

5. *Deadline-related challenges in research projects since March 2020*

- Due to the complete lockdown of physical facilities during the months of strict lockdown regulations, the researchers did not have access to their lab based equipment although for this particular institute, most of their research is done in remote forests and thinly populated areas. Hence the researchers could continue their research as they were in their respective research regions/zones when the lockdown restrictions were in place. Some of the other researchers who had lab-based work did see their research pace slow down along with their project deadlines and productivity.

- Another HoI shared that their institute was fortunate to have the adequate funding and productivity in terms of publishing papers etc. for their researchers to meet certain deadlines. However, due to delays and changes in the supply of scientific equipment there were a lot of delays in meeting certain deadlines that required the equipment to complete. So, although they had the funding allotted to meet specific deadlines, they could not meet them due to unforeseen delays in supply of scientific equipment.
- A HoI mentioned that almost all their department's deadlines were not met due to the lockdown restrictions that prohibited or delayed field work for data collection. User based design and policy cannot be done virtually, hence this particular HoI's research projects were stalled due to the pandemic.

6. *Change in roles and responsibilities as HoI since March 2020*

- One HoI mentioned that the role of the centre director has changed during the pandemic. Now the centre director has to be able to think about all future scenarios where the virtual mode of learning has to be implemented to some degree. There needs to be vision in terms of building permanent systems and infrastructure to enable virtual learning.
- Another HoI mentioned that their time is now mostly focused on looking out for COVID symptoms among their family members and their colleagues etc.
- One HoI shared that most of their role now became about managing the stress and worries of their colleagues and other staff within the institute. They initiated regular meetings and calls to ensure that their colleagues were doing well in terms of managing any of their worries brought on by the sudden pandemic. One of their policies was to also put in place flexible working hours for their colleagues.
- Time allotted to specific activities was in complete disarray during the initial months of the lockdown period, one HoI shared. They mentioned that due to added administrative responsibilities and managing other tasks apart from research and teaching was taking a toll on their mental and physical health. Some of them were isolated without their family, so they also had to manage their daily domestic chores along with work.
- Another HoI had a different experience to share in terms of time management: they mentioned that due to the reduction of in person meetings, they were able to devote more time to their research and writing and were able to catch up on the latest research in their field.

- There were added responsibility of overseeing and managing new COVID-related research and testing facilities for the HoI as well as managing the administrative and logistical details of such new ventures to provide COVID genome sequencing etc., one HoI shared.

7. *Category of institute employees that suffered the most*

- One HoI mentioned that none of the employees suffered during the lockdown period, there were only a few obstacles for the scientists who were required to conduct research in their labs and were unable to. Most processes and systems were made online before the pandemic so there weren't major disruptions in administration.
- Another HoI mentioned that the employees hired on a contract basis or were outsourced staff were the ones who were impacted due to the pandemic.

B. COVID-19 Effects on Funding

1. *Effects of the pandemic on funding for projects/laboratory/scientists*

- A HoI mentioned that for some of the scientists within their institute, funding deadlines were extended by 6 months and some of the fellowships were also extended.
- Another HoI mentioned that funding in terms of salaries have not been stopped due to the pandemic, although there has been extension in deadlines but there is almost always a no cost extension. However, with the threat of not being paid, institutions and Primary Investigators of projects have made arrangements for the scientists to be paid from other sources of funding.
- One institute that works in cancer research mentioned that all the funding for cancer research dried up during the pandemic. The HoI mentioned that they wrote to India Alliance regarding giving them extensions to use the funds allotted to them, but they weren't given extensions to use the funds for the project since there were disruptions caused by the lockdown. They also mentioned that there needs to be better funding support from a granting body like India Alliance especially during the pandemic. Although the institute has core funding and could cover the costs for the externally funded projects, there weren't many challenges in terms of funding.
- Another HoI had a positive experience in terms of asking for extension of funding from the granting bodies. Additionally, they were also able to spend time applying for and defending their grant proposal, which helped them continue their research. They also mentioned that scientists had to alter their research direction to fit the grants that were available during the

pandemic. The HoI also suggested that for increased access to internet connections, the government should set up cybercafés and in the local panchayat offices or collectorate's office to ensure that rural connectivity for students and other professionals who require the internet is increased.

- Another HoI mentioned that due to lack of time to complete writing proposals and conducting preliminary research, the scientists among their institute missed out on applying for funding opportunities. However, they are a small government funded institute and were able to manage funding and did not face any challenges.
- A HoI shared that there have been challenges in terms of funding and specifically the funds flow. From the funding provided by the government for ongoing projects there has been a delay of about 6-9 months for the funds to be disbursed due the slow bureaucratic process during the pandemic. However, they mentioned that they have not stopped paying their employees their salaries and have been trying to procure funds from other sources at this time. In terms of new funding opportunities most of the deadlines for applying and other timelines have been postponed especially from corporate funding for research.
- One HoI shared that from the Department of Biotechnology there has been a 40% cut in funding which is major. The institute has to divide the funding among three heads: salaries, equipment and general. So with the reduction in funding they cannot reduce the salaries of the scientists, so they had to reduce their expenditure on other equipment. There were no challenges in terms of applying for new funding because a lot of the funding agencies opened up many more projects and more COVID related research.
- Another HoI mentioned that a lot of funding that is based on collaboration and exchange visits between universities and research institutes which used to have a component for research has dried up. Most activities are now zero-funded, webinar type activities, so funding opportunities have reduced drastically. The institute itself has mobilised additional funds for COVID specific research and testing that has helped scientists and there are now new funding opportunities opening up with quick deliverables and a hybrid (physical and virtual) mode of research that is expected.

2. *Impact on the procurement of scientific equipment due to funding*

- One institute mentioned that the supply of scientific equipment was delayed due to lockdown restrictions. What used to take weeks to be delivered, now takes months especially in molecular equipment because there is a high demand for it due to COVID-19 PCR

sequencing and research institutes are on a low priority for it now. Most Indian companies do not manufacture it and it all comes from abroad, so this particular supply has been a huge problem. This delay in procuring scientific materials due to lockdown restrictions, lack of funding, disruption in supply chains have been echoed by 3 more HoI's during the interviews.

- Another HoI mentioned that there are challenges in terms of procuring materials due to the change in supply and manufacturing chains across suppliers of scientific equipment. Several suppliers have switched to manufacturing different products due to the market situation which has been a challenge for scientists.
- The delay in supply of new scientific equipment has delayed the advancement and upgrading of certain labs and research facilities, one HoI mentioned.

3. *Attrition rates within the institute since March 2020*

- One HoI mentioned that since they are a government run institute they don't have a HR policy like a corporate company and they haven't had any attrition among their scientists and PhD candidates.
- Another HoI mentioned that since their institute is also an educational institute, the student enrolment numbers have increased during the pandemic. The number of students enrolling in PhD programs have also increased.

4. *Changes in the institute's HR policy since March 2020*

- One HoI mentioned that there has been no change or delay in terms of salary of the staff due to no change in any government mandate.

5. *Impact on hiring due to funding since March 2020*

- One HoI mentioned that they have hired 12 new personnel but were not able to officially have them start working due to the pandemic related scenarios and circumstances, but were hoping to have them begin work very soon.
- Another HoI mentioned that all the hiring happened virtually for the institute and there were no challenges there.
- Another HoI shared that since they had core funding which is fixed, even during a pandemic they did not face challenges, however with the external funding agencies there was an issue with the funding.
- There were many new initiatives this institute wanted to begin for which they needed to hire personnel, but due to a funding crunch or delay they were unable to. Although they are

slowly picking up their initiatives and have hired, although not at the pace that they would have liked, shared one HoI.

- Another HoI mentioned that there was no challenge in hiring due to funding since their hiring cycles are very lengthy and all the planning was already in place before the pandemic hit.

C. COVID-19 Effects on Scientific Productivity

1. *Effects of the lockdown/remote work situation on the scientists' scientific productivity*

- One HoI mentioned that since their work relies on analysis of available datasets, their research did not suffer, although their own field-work for data collection was halted due to the lockdown. Some parts of their data collection was done virtually although this was not representative of the entire population as was regularly done during pre-pandemic times.
- Another HoI mentioned that the scientists who were working in wet-labs, with biological specimens or food technology research were the most adversely affected in their research. First, these specimens need to be maintained in their labs since they are living organisms and due to the remote working situation, they were not maintained or poorly maintained. Second, once the scientists return to their labs, they would need additional time to regrow their specific living organism that they conduct experiments on, thus further delaying their research projects.
- Another little discussed or little known effect of the delay in research and projects is delay in career advancement and development that scientists suffer. Due to slow/lack of research productivity, delay in funding and publications, participation in conferences etc. there will be a delay for those researchers who solely depend on research as their bread and butter.
- Due to the additional time available, a few scientists were able to get other research related tasks such as data cleaning, grant writing, manuscript writing done which they were not able to devote enough time to pre-pandemic. A lot of the scientists could organise and participate in research seminars and conferences that took place online too, one HoI shared.
- Another HoI mentioned that research in their domain could not be done satisfactorily through virtual mediums and the in person human interaction was a key component of their research. So while their colleagues in the department did move to an online mode of research through online surveys and online interviews, they were not satisfied with the level

and quality of data they were able to collect. Thus, their scientific productivity went down so they moved to focusing on helping and supporting their students during this time.

- Similarly, another HoI mentioned that while they were able to have remote data collection and were able to publish their research, they could not have policy recommendations or real life applicability of their research since it was done with little to no in person human interaction such as field work. This has adversely affected their scientific productivity and the impact of their research.
- Interestingly, another HoI mentioned that it's too early to see the actual effects of the pandemic on scientific productivity. Since academic publishing life cycles are very long, the effects of the pandemic can be seen only after a year or so. The real measure of scientific productivity will be the number of publications that will tell us about productivity during this time. There were several training programs that the scientists conducted as well which were stopped due to the pandemic, so that has had an effect on their productivity as well.

2. *Proportion of time spent on research, administrative duties, research supervision, teaching etc and the pandemic's effects on these activities*

- A HoI mentioned that due to the lack of access to physical laboratories, a few researchers found more time to write papers and book chapters and apply for grants which they were unable to do due to lack of time before the pandemic.
- Another HoI mentioned that during the pandemic it has become evident that a lot of work can be done remotely and still be done effectively. Especially in academia a lot of the reading and writing work can be done remotely. However, the HoI mentioned that the biggest loss for academia is the in person communication either through learning or teaching or working with colleagues and other scientists.
- Several scientists mentioned that the time spent on administrative and other support responsibilities as HoIs took up a lot of their time as time spent on other activities such as teaching and research and assessment etc.

D. COVID-19 Effects on Teaching

1. *Transition to online examinations, lectures, teacher assessments in a supervisor's capacity since March 2020*

- One institute put in place a Virtual Learning Academy for its students and faculty, this enabled the faculty to first get trained in conducting online lectures. There were many errors

in the first few months but after a year the online lectures including assessments went smoothly. During this time, there was also continuous feedback from the students in order to improve their learning experience, which was also a good learning experience for the faculty, and also a good learning experience for the faculty to pick up new skills.

- A few HoIs mentioned that practical assessments for their students was not possible since all teaching and learning was taking place virtually. This posed a challenge in terms of designing similar assessments that could be done virtually.
- Another HoI mentioned that faculty is using the help of digital teaching aids such as animations, simulations and videos for their students via virtual teaching methods. However, they also mentioned that the quality of teaching has gone down considerably.
- Apart from the regular teaching, the faculty had to also deal with answering questions from students regarding the lockdown and other challenges they faced during this unprecedented time, such as dealing with families and other uncertainties such as financial difficulties and mental health challenges. The HoI mentioned that a lot of the students were not focused and many could not cope with the shift to online learning.
- Another HoI mentioned that since they do not have undergraduate or masters level students in their institute they did not face a lot of challenges with the PhD level students who attended a few lectures online and were mostly involved in self-study etc.

2. *Specific requests/challenges from the teachers and students vis-a-vis the transition to online mode of teaching and assessment*

- Most students cannot afford a digital device such as a laptop or a mobile phone, or they have to share a mobile phone between several members of their family. Often the costs for internet connection/data packs for an entire day (for online classes) are too high for most to afford. This leads to exclusion of several students from their classes and from learning. This also creates a lot of difficulty in the student-teacher relationship.
- Managing a syllabus over the almost overnight shift to online classes was tough for most faculty within one institute. The faculty had to move to creating and using Google classrooms to continue online classes for the students of the institute. However, there was help from other technical institutes to maintain and manage the online teaching and learning systems.

- One institute set up a learning counselling group for their students. This was done through meetings with a small group of students and one faculty member and any difficulties the students were facing were discussed.
- A HoI mentioned that within the institute, the students who belonged to the food engineering, technology and civil engineering were the most adversely affected due to the lack of access to physical facilities and laboratories.
- From the interview, one HoI mentioned that the biggest sufferers of the lockdown restrictions and the subsequent shutting down of institutes were the students. The student belongs in a place of learning and they need to be there physically in order to make the most of their learning experience. There are too many technical, financial and familial/home related obstacles that hinder the smooth functioning of online learning and teaching.
- The faculty at one institute found it challenging to frame and design assessments for their students to minimize duplication of work and for the students to be engaged. The HoI mentioned that it was difficult to keep the students engaged when there is easy access to so much more information over the internet. It is also difficult to assess how much the students have learnt and understood, hence the grading system was changed to allow for grades depending on attendance in their online classes.
- A lot of students were also fortunate to have their parents who were either educated or could help them out with their studies and coursework etc, however for those students who are not so fortunate, they were at a disadvantage especially during the pandemic when social interaction and support from faculty and peers were not as effective as in person interactions are.

E. COVID-19 and Social Support

1. *Institutional support for the scientists and other staff during the pandemic*

- Several HoIs mentioned that they were connected to nearby hospitals for emergencies for their staff, they also procured essential supplies of oxygen concentrators, pulse meters etc. They also conducted vaccination drives for their faculty and other staff at the institute.
- Two-three HoIs mentioned that they provided flexible working hours for their employees, they had social support in terms of weekly catch up calls, emergency medical help and other services that were coordinated among their teams. They also bought or paid for internet charges/routers/dongles for their employees when needed.

- Another institute provided software for research and teaching, along with web-cameras for online classes and meetings
- Some of the students at the institutes who were unable to pay their tuition fees on time were given flexibility or concessions in terms of the fees, the institute also provided scholarships for a few students from economically disadvantaged backgrounds. The institute also provided stationery and other hardware grants for their faculty.
- A few funding agencies did grant extensions for the scientists at one institute, a HoI mentioned.
- Another institute provided designated counsellors for their students and faculty. Echoing the need for mental health support, another HoI mentioned that the senior level management or head of institute are also severely stressed in spite of their experience and age during these pandemic times. They mentioned that it is difficult for them as well to distinguish between family and work and maintain a work-life balance. Often the emotional health of senior faculty and staff at any institute is taken for granted and during the pandemic, their own stability, health and perceived authority was really tested, mentioned one HoI.
- One HoI mentioned that his mental health and that of his colleagues was one of the biggest adverse effects of the pandemic. Due to the extended work from home mandate, regular life was abruptly halted and with it a lot of social interactions that adversely affected the mental health of the faculty and staff. This also brought on added lifestyle related diseases such as hypertension, blood sugar and blood pressure. Due to no real life interactions between students and faculty, and among colleagues there has been an adverse effect on the mental health of everyone associated with the institute.

2. *Specialised institutional support for members of the institute with childcare responsibilities*

- Most HoIs mentioned that support for staff who have childcare responsibilities was the same as during the pre-pandemic and that there were no specific policies put in place.

3. *Specific grievance redressal mechanisms since March 2020*

- Most HoIs mentioned that they did have counsellors and psychologists in place in terms of dealing with the emotional and mental stress and pressure that students and faculty faced during the uncertain pandemic.
- Several HoIs mentioned that there were grievance redressal cells or mechanisms in place pre-pandemic at the institutes to deal with sexual harassment or any other complaints

regarding staff and students but there were none that were instituted specifically during COVID.

- Another HoI mentioned that although they had the help of a counsellor, there were so many uncertainties that were taking place due to the pandemic that there was no way people could respond to it effectively.

4. *Scientists within/outside of the institute who have left academia or are planning to quit academia since March 2020*

- One HoI mentioned that the funding crunch during the pandemic has hit the middle level researchers the most and those who are starting out in their careers, they have noticed a lot of them leaving academia for this reason.
- Another HoI mentioned that on the contrary they have seen a lot of people who have joined academia during the pandemic and that it's not a very wise decision to leave academia during this time because this is one of the most stable jobs available right now. Similarly, another HoI mentioned that people have moved from industry to academia based jobs during this time.
- Another HoI mentioned that some from their institute had to leave academia due to personal reasons but not due to COVID.
- Another HoI mentioned that they have had a very high level of retention during the pandemic.
- To deal with the stress, another HoI mentioned, the staff and faculty do not quit but instead take frequent breaks and sabbaticals. Even though there are problems with academia, not many are willing to leave prestigious and stable jobs such as those at the IITs.

Funding Agencies Responses

Of the 22 funding agencies approached to participate in the study, only three agreed to participate. Between the three, they fund research in India in the range of USD 14 million, 108 million, and 344 million (only the last figure is for global grants funded). Thus, each operates at a different scale, thematic funding area, and in varying geographical contexts.

A. COVID-19 Effects on Research

1. *Impact on the research output of an institute/laboratory/scientist that the funding agency has funded*

- The pandemic accelerated their funding in terms of supporting studies on health and nutrition. A lot of organizations pivoted to conducting their research via telephonic interviews and mobile phone based surveys for their data collection which resulted in an explosion of data-collection methods and efforts in response to the pandemic and its effects on lives and livelihoods. All the organisations the funder supports paused their field based work and research. Due to this pause, the organizations were unable to utilize the funds they had set aside for field work. So in terms of research being impacted due to the pandemic, it's not a clear answer: there were types of research that were halted but there was a lot of research that still went on.
- Another funding agency that also conducts their own research mentioned that with their existing projects, when the pandemic hit, they had to quickly assess the potential scenarios that could take place. This included increasing the geographical reach of their research study. They also utilised their contingency funds for additional research personnel on the research study due to current research team members falling ill due to COVID-19.
- Due to lack of access to their labs and research work, a lot of scientists could not meet their deadlines in terms of deliverables and funding timelines, one funding agency mentioned.

2. *Effect of the pandemic on ongoing research and future funding timelines*

- During the pandemic, research projects were affected and one funder mentioned that for their own research study they had to consult and convene their technical advisory group more often to seek responses from them to make changes to their existing protocol in terms of adopting different research methods. Each scenario was planned and discussed with the technical advisory committee and with different stakeholders in the research study.

B. COVID-19 Effects on Funding

1. *Type of research institutes/scientists typically funded by the funding agency*

- One funder only funds individual scientists (at different universities/organizations/institutes) at different stages of their career and not entire organizations/institutions.

2. *Change in funding policy since March 2020*

- In terms of already funded projects and organizations, one funder mentioned that they gave the organizations no-cost extensions so they could utilize the funds that were allocated for activities that were halted due to the lockdown restrictions. A lot of the implementation was halted and the organizations were given extensions. The same funder also mentioned that

there has been repurposing of funds such as funds directed towards developing new and better ways to measure household expenditure on health, also towards the impact of COVID-19 on households.

- Another funder mentioned that they provide no-cost and cost extensions for the organizations they fund. All the organizations were in need of no-cost extensions and the funding agency mentioned that they usually make payments based on deliverables. The funder mentioned that there are clauses in the contract that certain payments will be made based on the deliverables. There were several negotiations with the organizations that involved adjusting the deliverables, to address the payment processes and for the no-cost extension, including extending timelines.
- Another funder mentioned that they have a fixed fund flow so they ensured that they received funds in time to be able to pay their individual scientists who they fund. There were no delays from the funding agencies side in terms of payment to the scientists. In some cases they have relaxed a few clauses to minimize inconvenience for the scientists during the pandemic. In some exceptional cases the scientists this funding agency grants a no cost extension where there are justifiable extensions in terms of the work the scientist has done or their specific situations.

3. *COVID-19 related research funding since March 2020*

- Due to COVID-19 there has been an increase in certain research areas such as towards the increase in poverty due to loss of livelihoods brought on by the lockdown restrictions in India. Related areas of research and funding are food insecurity related to the pandemic in India, mentioned one funder while explaining the research funding from their funding agency.
- Another funding agency mentioned that they did not start a COVID-19 specific related call or any COVID specific initiatives for research funding. They did enable dissemination of crucial COVID-19 related research and to pass on the right information during the pandemic by creating online public engagement with scientists who are experts in the field of virology and public health.

4. *Specific demands related to funding from the scientific community since March 2020*

- One funder mentioned that there have been specific areas of funding that have emerged due to the pandemic. These include the importance of strengthening surveillance systems,

new methods to engage in surveillance, and building capacity to conduct sero-surveillance studies which are now being prioritised due to the pandemic.

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C. COVID-19 Effects on Scientific Productivity

1. *Effect on project and funding timelines since March 2020*

- The pre-pandemic research agenda has definitely been affected and timelines have been extended. Although a lot of the studies that the funder has supported that are directly related to the impact of the pandemic have been conducted rapidly due to the pressure to generate answers and eventually positively impact policy. There have been a lot more team-based collaborations in all fields of science that have taken place during the pandemic, this has also resulted in new networks and collaborations across civil society and government.
- Another funder mentioned that since they fund mostly hospitals to conduct research, their research capacity and hence their research output went down significantly. Most hospitals and their staff were involved with COVID-19. The entire research cycle was disrupted due to non-availability of researchers and peer-reviewers. Since none of the research was happening on time, a lot of other processes such as dissemination webinars did not take place or were significantly delayed.
- Another funder mentioned that an important metric for measuring scientific productivity is publications. The funder mentioned that they ensure that all publications remain open access for which they bear the costs. The funder also mentioned that the scientists they fund are open to choose the platform to publish their work.
- One funder mentioned that they ask the scientists they fund to submit every project report. During the pandemic they have relaxed or extended these timelines for submissions of certain deliverables from the scientists. The funding agency also mentioned that they are trying to speed up the process of the payments that follow the submission of each project report to ensure that the scientists' payments are not delayed due to administrative processes. They have also made allowances for when scientists or their family members have been affected by COVID-19. This is the same procedure they follow for potential new hires that might miss an interview due to an illness or travel restrictions during the pandemic.

2. *Provisions for research finding dissemination*

- A lot of scientific dissemination has been done via webinars and online outreach. These online programs really improved access for many across the globe. A lot of the scientific

discussions on findings from research and impact on policy became much more nuanced and collaborative since such discussions moved online. Two other funding agencies echoed these views.

- Another funding agency also mentioned that they have started podcasts and other online events for wider public dissemination of research findings by scientists and to improve awareness regarding the COVID-19 pandemic. The funder also mentioned that they have regular newsletters that provide details on the latest research that has been published.

D. COVID-19 and Social Support

1. *Support to research institutes during the pandemic*

- One funder mentioned that apart from funding they have not provided much support. There is definitely a big psychological impact of the second wave of the virus that India witnessed in 2021 which affected people directly and indirectly, the same funder mentioned. However, as a funding agency they did tell all the organizations they support that they cannot lay any of their employees off and they need to continue paying their salaries on time. A lot of the funding agencies need to provide cost extensions. There is also a danger of funders going back to business as usual without thinking of the implications of another surge in COVID-19 cases that will disrupt work and timelines once again.
- Another funder mentioned that they did not provide any support directly related to COVID-19 due to their orientation as a development related funding agency and not a humanitarian agency. They were only able to provide training for staff at certain organizations that was required during the pandemic. They were able to provide IT support and digital training support to the staff of the organizations they work with. They also conducted workshops with global experts that helped them create digital modules and training guides which were used for training research staff in India. The funding agency also extended their flexible spending percentage of their budget from 10 to 20 percent that allowed organizations to use those funds for COVID-19 related relief efforts. Along with this, the funding agency also has an organizational wide assessment tool that identifies the strengths and weaknesses of the organizations they fund. They then help the organizations become stronger and more sustainable in terms of their structure and functioning by helping them with identifying their strategic goals.

- Another funder mentioned that they have a lot of flexibility in terms of the funding they provide to their scientists. There is a certain amount of funds that is allocated for flexible spending for the scientists, they can use this for travel, attending a meeting/workshop/conference or buying hardware/software. This allows the scientists to choose their own type of social support they need that the funding allows. They can also use the funds for another component, for example, the funder mentioned that during the pandemic since travel was restricted, the funds allocated for travel could be added to the experimentation/research component of the scientists work.
- One funder who only funds individual scientists and not institutes mentioned that social support is provided by the scientists' institution or organization they are affiliated with. They cannot provide social support without crossing fine lines of institutional boundaries. For the employees of the funding agency they provided wellness workshops that included yoga and meditation. They also coordinated slots at vaccination camps close to their employees. They had regular check-ups and meetings to ensure that they built camaraderie among team members. They also started a holistic organization level multi-dimensional tool that evaluates different aspects of the team's performance and wellbeing and engagement etc. they also started flexible working hours during the pandemic and ensured no one was overworked or worked over the weekends.

Suggestions from the funding agencies interviewed

- One funding agency did mention that organizations need to think of redundancies that are built into their organizational structure. The leaders of organizations were also affected during COVID-19 including members of research teams and everyone involved. There needs to be a plan of succession and scenario planning to ensure that teams and organizations run smoothly in case their members are affected, also that the organization has a direction even if their leader/head is not able to work or is affected directly or indirectly by COVID-19. There needs to be a crisis response plan in place within organizations and within teams that improves the resilience of the scientific community.

Suppliers of Scientific Equipment Responses

Close to 40 suppliers of scientific equipment were approached to participate in the study, only four agreed to participate. The four suppliers conduct business in products such as high end imaging

lenses, equipment for clinical diagnostics, nuclear research supplies and telescopes. Each operates at a different scale, products, and in varying geographical contexts.

A. COVID-19 Effects on supply of scientific equipment

1. Challenges associated with the supply of scientific products since March 2020

- In a lot of cases the shipment was delayed due to restrictions on transportation and travel during the lockdown period. They also had to pay late delivery charges/additional shipping charges due to this. Due to the delay in supply of the equipment there was delay in the instalment of the equipment as well.
- During the pandemic there was another challenge due to the policy of not accepting a tender from companies that had any part of their supply manufactured in neighbouring countries. So for example, almost all manufacturers have parts manufactured in China so they are/were not able to sell their products in India. This is a very tedious process and policy that was a major obstacle to the supply of scientific equipment.
- One supplier mentioned that within the country there weren't many challenges in terms of transportation of equipment. The correct documentation had to be obtained and shown wherever it was asked for. Although there was a slight delay of a couple of days due to lockdown restrictions.
- Another supplier mentioned that since they are the only company in India that supplies scientific instruments for nuclear research all their meetings and marketing have to happen in person because the institute or company buying from them needs to be able to experiment or test the instruments. For this supplier, there were many challenges presented by the pandemic: they had placed orders that could not be fulfilled due to delays in manufacturing and this affected them financially as a lot of payments were also left pending. There were also delays due to unavailability of government officials for documentation and necessary permissions.
- One telescope supplier mentioned that during the lockdown period when home delivery services were operational, their business picked up because everyone was buying telescopes during that time. Due to the increased availability of time and clear skies due to reduced pollution there was a steady supply of telescopes during the lockdown months. The supplier mentioned that they are already placing orders in advance with factories/manufacturers for

more telescopes. However, globally manufacturers are facing problems due to shortage of raw materials. During the lockdown the supplier mentioned that they were dispatching 20 boxes everyday and now once restrictions have been lifted, they are dispatching around 3-4 boxes everyday.

- The freight delivery charges have gone up during this period and that means that the cost of the equipment has also increased (up to three times). This cost was borne by the supplier.

2. *Specific demands from scientists/institutes vis-a-vis scientific equipment since March 2020*

- One supplier mentioned that all the demand for equipment has turned towards COVID-19 testing and diagnostics and research on the different strains of the virus.

3. *Change in primary target market/group since March 2020*

- There has been no change in the target group or in the type of products they sold/sell during the pandemic, one supplier mentioned. The demand has started increasing again, but very slowly. The problem with manufacturing has been the push towards local manufacturing that increases the time taken to process the paperwork required and to procure the product, hence the supplier mentioned that foreign suppliers should be allowed to bid in the process as well. This is a huge setback due to the policy implemented by the government that harms the entire process of bidding for a tender, manufacturing and supply of scientific equipment.
- Another supplier mentioned a similar challenge they are facing due to change in government policy during the pandemic in India. The Government of India has come out with some new regulations and policies where in India you can only apply for central government tender in Indian rupees earlier foreign companies to port directly for the Indian tenders, but now, they are only accepting gigs in Indian rupees. So, several foreign companies were interested in selling their products. The scientists helped the suppliers to connect with those companies so that they could import the equipment on their behalf India and then sell it in Indian rupees. Second policy is the Make in India policy which includes a 20% value addition in India. So, a lot of companies wanted to outsource some parts so that they could fulfil this 20%. So that is a new growth avenue for the suppliers. However, the supplier mentioned that they are not sure if it's a feasible policy in the long run. Especially for scientific instruments in India it is a limited market and the type of equipment they sell is a very specialised device and is not sold in bulk which involves only five orders in the next three years or four years. This makes it very difficult.

4. *Digital mode of marketing scientific equipment since March 2020*

- Online interaction has increased, one supplier mentioned as a positive. The business has also moved towards increased digital marketing and they are working on new methods of digital marketing, but online systems are not very effective. The best way is to physically demonstrate the samples to the customers which builds their confidence but that is not possible with the online method, the supplier noted. The system performance/the quality of the sample cannot be demonstrated online and nothing can replace the in-person mode of marketing.
- Another supplier mentioned that client meetings and negotiations are now all taking place virtually which helps the process and makes it easier. The supplier mentioned that now government agencies are going through it as well.
- One supplier mentioned that they are not doing anything specifically with respect to digital marketing during the pandemic. They mentioned that they were busy with their daily work and that they did not have time to set up their social media presence, although they have an extensive website already in place and will be adding an e-commerce module to their website soon.

B. COVID-19 Effects on Funding

1. ***Impact on supply due to a change in funding that research institutes/universities received since March 2020***

- A lot of their funding was delayed due to the pandemic and lockdown. All the payments that they were owed were delayed and they experienced a financial setback.
- The supplier also felt that funding has decreased due to the funding being diverted towards COVID related activities.
- Another supplier mentioned that there were no changes in funding or payment from customers and they did not need to take any loans from external sources so they did not face any challenges there. They do not take any credit and accept advance payments from everyone.

2. ***Change in payment terms since March 2020***

- One supplier mentioned that terms of payment have not changed but due to the institutes remaining shut during the lockdown period, there was a delay in the installation of equipment which delayed the payment for the equipment as well. The suppliers had to pay

the manufacturers since they bought the equipment but they did not receive payment from the institutes since the installation did not take place. The supplier also mentioned that there is a relaxation from the government where they have waived the fees that the company or bidder pays the government. The bank guarantee percentage amount has also been reduced from 10 to 3 percent which is done to support companies that are going through pandemic induced challenges, the same supplier mentioned.

- Another supplier mentioned that there was no serious delay in payments from customers and other research institutes and from the government as well. The process is very streamlined and organised now, so there are minimum delays in payment.
- Another supplier mentioned that earlier the suppliers in order to bid for a tender had to provide a bank guarantee to the customer, but these terms have now been relaxed from 10 to 3 percent. Another term that has been relaxed is the payment: earlier after the device/instrument was installed the payment took another 30-60 days to be made, now the standard terms are 80 percent of the payment on delivery and 20 percent after the customer/institute has tested the device/instrument. The government has tried to streamline the process for vendors and suppliers. However, the supplier also mentioned that they are not sure how these new terms will play out and if they will be beneficial to them in the long term.

3. ***Changes in the company/organisation's ability to gain funding/loans/other investors since March 2020***

- One supplier mentioned that the government has contributed in a positive way during the pandemic to help small businesses by instructing national banks to provide MSME loans. This also includes subsidies that benefited small manufacturers that also helped the suppliers.
- Suppliers usually work with bank funding in overdraft facilities. However, during the pandemic one of the suppliers wanted funds from the bank that they were promised earlier and the bank was very strict in their terms of payment which made it difficult for the supplier to work with. This supplier mentioned that they wish that the government did more in terms of funding from banks for businesses and ensure easier access for businesses that are recovering from the pandemic.

Suggestions from the suppliers interviewed:

1. One supplier mentioned that the basic science research should not get excluded or left behind due to lack of funding during the pandemic. The government needs to invest more in other pure sciences as well for better and improved research capacity.

Case studies from the other stakeholders in Indian STEM (4)

In addition to interviews with funding agencies and suppliers, specific stakeholders working in Indian STEM were also interviewed that do not fall explicitly into these categories. Their responses are presented as individual case studies below.

Case Study 1: Centre for Cellular and Molecular Platforms (C- Camp)

C-Camp was founded in 2009 and is based in Bengaluru, Karnataka. It is an organization supported by the Department of Biotechnology (Government of India) largely to catalyse high-end research and innovation in the field of life sciences. There are three verticals at C-camp: technology platforms, early stage deep science entrepreneurship, and research translation and commercialization. C-Camp coexists with two other organizations: the National Centre, Biological Sciences, and stem cell Institute for Regenerative Medicine. Together they form the Bangalore life science cluster.

Effects of COVID-19

- As lab work is dependent on in-person work for the teams, new ways of looking into how the basic minimum work could be continued had to be devised. A lot of their work was also related to COVID-19 diagnostics development.
- C-Camp devised new ways such as getting people on campus in multiple shifts, so people could work, ensuring availability of resources and reducing challenges and difficulties for their employees. However, in spite of these new arrangements in place, they mentioned that productivity was definitely impacted during this time
- There were delays in purchasing and selling equipment to consumers for C-Camp but due to the pandemic being a global issue, these circumstances were unavoidable.

Changes in supply chain and availability of scientific equipment due to the lockdown

- In terms of impact on supply chains for scientific equipment, for C-camp there has not been any change and the supply chains have remained more or less the same as pre-pandemic.

However, there has been some effect: some of the equipment is built globally and there have been restrictions globally that have affected the supply chain slightly. But they noted that there isn't a huge shift in terms of their availability to continue work.

Funding Challenges

- There has been a challenge in terms of funding since all the funding has been diverted towards COVID-19. They remarked that hopefully the funding will return towards the broader sciences that supports more than just COVID-19 research.
- During this time, there has been no new funding from the government. The funding available for regular scientific projects was taken away due to focus on the pandemic.
- A continuous source of funds is required to run labs and to continue paying scientists who work in the labs, including supporting the infrastructure costs. They noted that the gap in funding that they are experiencing now has to be made up for in the next year through various sources of funding.
- For the start-ups, the funding challenges are immense, since most of them had started receiving funding when the pandemic started. The impact has also been larger on smaller institutes, not central government funded research institutes.
- The start-ups were not able to deliver on their work due to funding challenges. Many of them had to let go of their employees.

Change in research methods

- The scientists who were working in the related field of virology have pivoted towards COVID-19 based research.
- Other scientists who could not pivot towards another research area due to lack of funding have definitely been impacted. They noted that it's important for labs and universities to ensure that their project associates and PhD students are not going to be affected due to a reduction in funding.

Suggestions from C-Camp on improving conditions for STEM researchers in India

- They remarked that there needs to be more funding and support for scientists and research that takes place outside of centrally funded institutes. There are only a few research institutes that are well supported and funded, there needs to be more funding for other institutes as

well. There needs to be a big policy level change, in phases, to support this push for more equitable funding decisions by the government.

Case Study 2: Institute for STEM Cell Science and Regenerative Medicine (INSTEM)

The Institute for STEM Cell Science and Regenerative Medicine (INSTEM) is an autonomous Institute of the Department of Biotechnology and is located in Bengaluru, Karnataka. They are part of the Bangalore Life Sciences cluster, along with NCBS, National Centre for Biological Sciences and C camp- centre for cellular and molecular platforms. At INSTEM, the primary focus is on clinical translational research. They develop a variety of research based solutions and develop technologies that aim to meet clinical needs. Apart from scientific research and development of technology, INSTEM aims to take the technology to the next level by practising entrepreneurship. They try and translate these technologies into viable product centric to the industry. They either identify an existing industry and license their technology to them and then co-developed it with them and take it to the final stage. Or they form a startup company and transfer the technology to the startups, and then from the startup develop technologies for the market.

Effects of COVID-19

- Due to the lockdown related restrictions a lot of research at the labs and institutes has stopped. The only way they could contribute to the current public health emergency in the country was to start testing centres. Being a biology institute they quickly set up testing centres and worked with local hospitals to help them with COVID-19 diagnosis. All the students and PhD candidates and postdoctoral candidates helped in and learnt the techniques quickly and they contributed their working hours to helping with the testing and diagnosis.
- There were several logistical issues during that time such as staff travelling who needed to come in and maintain the equipment at the labs and the infrastructure of the institute. They were able to arrange accommodation for some of the staff on campus and they maintained very strict COVID-19 protocols on campus.
- Although there was an impact on research output, the COVID-19 protocols that were put in place were extremely useful and prevented a major calamity.

Positive Impact

- One of the positive developments in terms of mask technology during the pandemic was developed at INSTEM. This technology has had a huge impact in terms of protection by reducing the possibility of infection rates. This was developed at the lab at INSTEM via setting up a research program and to quickly translate this technology to the next level it was taken to a startup and then eventually for manufacturing. The products developed with this technology were already in the markets within 6-8 months.
- They remarked that there are several other technologies that can be developed and translated to an industry level in record time but other processes such as testing and choosing a manufacturer take time.
- There were several challenges during the lockdown in terms of selling the products in the market due to the restrictions. These challenges were resolved by selling their products in smaller cities and towns as well.

Decision Making

- Decisions were made on the number of people that could be accommodated given the new COVID protocols, the type of research that was relevant and of value. All the decisions were made collectively and questions such as: what is the best way forward? And what is the need of the hour that requires focus and an investment in resources, time and people? Were asked in order to make the correct decisions.

Effects on Funding

- Running labs and maintaining equipment is expensive and funding was challenging for INSTEM.
- There are fewer grants available during the pandemic and the grant cycle is a very long process. Most of the existing funds have been diverted towards other COVID related projects and hence the regular stream of funding has depleted. A lot of the funding has been delayed as well.

Suggestions from INSTEM regarding improving conditions for STEM researchers during the pandemic

- For regulatory bodies that oversee vaccine development the process typically takes 10 years from development and clinical trials and looking at the safety trials etc. With the pandemic, it has been proven that a lot of these stages can be revisited in terms of looking at vaccine development and delivery. There is a lot of bureaucratic work that slows down a lot of vaccine development. The process needs to be made more efficient and for that we need to revisit a lot of the processes.

Case Study 3: Cloud Krate

Cloud Krate was set up to fill the gap between suppliers of scientific equipment and between research institutes and scientists. Typically the entire process of ordering and getting the equipment delivered to the research institutes takes a very long time. The company started looking into what are the problems from both ends of the supply chain and what causes the delays and how they can be addressed. In 2019, the company was registered as a private limited company and they began fundraising. They mostly deal with life science companies, research institutes and diagnostic labs. They offer not the product itself, but intelligence on the product: Crucial information such as the price, its quality, its availability, the brands available, reviews and recommendations from peers in similar fields of science. Often, they get queries from scientists or labs working on certain experiments that require certain equipment and Cloud Krate fills up this need by providing the correct information. They do not function as traditional suppliers as they stock very few products but have a large network from which they are able to procure the products on time.

Impact of COVID

- During the first lockdown phase there were major delays in terms of supply since almost all foreign shipping routes were shut down and prioritised for COVID-19 products. Certain brands were not able to supply certain equipment since all their resources and attention was diverted towards manufacturing for COVID related products. On the research front, the campuses were shut so scientists could not access their labs for their research work.
- Funding had been diverted to COVID-19, there was a massive increase in people wanting masks and PPEs etc. there were a lot of new customers such as housing societies approaching Cloud Krate and ordering masks and sanitizers etc.
- As the campuses started opening up, there was a sudden influx of orders from scientists and there were older orders that also had to be fulfilled. Since a lot of the older orders were

coming in due to the delays there was a lot of analysis that had to be done in terms of expiry dates and inventory taking etc.

- A lot of the products were also being sold at marked up rates due to their high demand during the pandemic, such as medical gloves. There were certain parts of products that were not available due to the delays in global supply chains.
- During the second wave in early 2021 in India, there was a huge surge in demand that they found very difficult to meet.
- Now, there are a few manufacturers who have had the time to think about the impact of the pandemic and have revised prices on certain products.

Positive developments

- Since several traditional suppliers rely on a foot-on-the-ground model, they were not able to rely on this model for marketing their products due to COVID restrictions and campuses being shut. Cloud Krate always had a WhatsApp based model via which customers could place orders and this continued during the pandemic as well.

Digital Marketing

- Cloud Krate started in 2017 and they started with developing an application for their work and also a marketplace page. However, the marketplace page did not receive much attention and was not used. The application was not used by the scientists as they were too busy and did not want to waste time comparing products etc.
- After spending funds on the application they decided to set up a WhatsApp business account and the number of their queries started to increase. WhatsApp was a much more convenient platform for people to ask their queries and inquire about different products. People were also more responsive since they wanted to talk to a human being rather than a bot or an automated response application.
- The WhatsApp business platform helped connect people from both the lab side- the scientists- and the suppliers. The suppliers were also facing challenges in terms of their shipment getting lost or misplaced during transits at different facilities and airports. There was no way to solve these problems digitally except over the phone and actually talking to people.

- The COVID-19 pandemic reinforced their model of having the WhatsApp business platform rather than moving through a digital mode. They might think of other platforms too for their business.

Case Study 4: India Bioscience

India Bioscience is a project based at the National Centre for Biological Sciences, Bengaluru that works with multiple stakeholders in the scientific community in India. It works with funding agencies, with academics, it works with students, with stakeholders from the private sector. India Bioscience acts as a facilitator of change, it tries to highlight the existing science in India and within the Indian scientific community. It tries to foster dialogue as a kind of Central organization around which the bio sciences in India can grow, develop, and evolve. India Bioscience is extensively supported by the big funding agencies of India, such as the Department of biotechnology, they are a primary source of funding. They also get support in various forms from various community organizations and institutions in India. They have always been a smallish team, currently they have six full time people working. In their role as facilitators or catalysts, although they have a small team, they work a lot with the community. They are able to do a lot of science communication through their website, and they also advertise a lot of opportunities, jobs, grants etc. they also have several independent writers and a small facilitation team that works with the main team at India Bioscience.

Effects of Pandemic

- With the pandemic, the Indian government including the Department of Biotechnology put out special calls related to pandemic funding. However, they noted that this can benefit only a certain fraction of people if you were not already working in fields such as virology.
- It was noted that there were probably not many big changes that were made to existing research by scientists to fit the COVID-related granting opportunities available. The way science progresses is not as rapid as it has been during the pandemic, it is usually in gradual and incremental terms. Several non-COVID related granting opportunities have not been scrapped completely; they still exist, but it was noted that the timelines (in terms of the funding timeline due to paperwork and documentation) have become much longer. This is probably due to how the economy was affected.
- Although the funding opportunities have been plenty during this time, in reality there were several researchers who have not received funding or they have been delayed payments.

- Indian organizations and granting agencies are now exploring collaborative international grants. International granting policies have been very generous in terms of extending timelines and paying attention to research needs of scientists during the pandemic.
- Pre-pandemic, India Bioscience used to organize meetings and events for researchers and scientists. These events were used for skill building and networking. They adapted this onto an online platform and there were a lot of advantages to this: they were able to access a lot of otherwise unreachable audiences/researchers from across the country and increase the activities they organize. They plan to permanently adopt a hybrid model of science communication.
- They were also able to collaborate with other organizations to increase COVID awareness and to combat COVID-related misinformation in India.

Positive Impact

- The pandemic has brought forth the importance of and the possibility of improved inclusivity and diversity that can be supported through the virtual medium. This should not be forgotten right in-person events are possible once again. Several people from across the country and a few from outside the country were able to participate in webinars, people who had other commitments were also able to participate because these events were virtual.
- Work from home arrangements have also been more accepted now; earlier it was frowned upon in workplaces. There are people who prefer working from home due to family or financial reasons or they are able to work better from their own homes. These are some learnings from the pandemic that must be retained going forward.

Staff/Employee support

- In terms of employee support, India Bioscience has set up weekly informal meetings with their employees to check-in with each other and to provide a platform for socialising which would have taken place in an office setting earlier. This way employees could keep in touch with each other and share non-work related information and to reduce any stress that people are experiencing.
- A few other labs are setting up journal clubs and other kinds of discussion groups weekly. NCBS has started town hall meetings where everyone in the organization attended online, there have also been more open conversations around counselling facilities.

Effects on Funding

- There was a shortage of materials and equipment that were needed in labs during the pandemic. Due to the sudden shutdown during the first lockdown phase, there was almost no time for people to respond and no one knew how long the lockdown would last.
- There has been a huge delay for graduate students in terms of their professional timelines/career trajectory/parallel personal milestones that have now been disrupted due to the pandemic. Graduate students who might be the sole breadwinners for their families have had their funding for their labs stopped or delayed during the pandemic, which has deeply affected their livelihoods.
- There is a huge sense of isolation that the remote working arrangement has brought about that is deeply affecting the researchers along with delays in work timelines and funding delays creates a sense of uncertainty and a lack of clarity for many researchers. The lack of in-person interaction among your peers and colleagues creates a sense of isolation.
- There are researchers who have set- up their own labs during the pandemic but were unable to recruit postdoctoral researchers to work in their labs. For postdoctoral researchers, there are very short timelines to create an impact in their field of research, so the pandemic has created a disruption for close to a year now and that has caused additional stress for these researchers.
- There are researchers who are now on accelerated timelines once they have gained physical access to their labs to make up for their lost time which is leading to additional stress of personal and professional milestones.

Suggestions from the interview with India Bioscience regarding improving conditions for STEM researchers in India

- Recommendation for a funding agency is maintaining the pay for all their graduate and postdoctoral researchers in their labs and ensuring there are minimal delays.
- There is a need for funding agencies to reduce their bureaucratic processes and other administrative delays to prevent any inconvenience for their grantees in terms of delayed

payments. Even for an extension in terms of funding, there's a lot of resistance in the system towards change.

- It's important for funding agencies to have an open line of communication. Any reasons for delay must be communicated at the earliest to the grantees to ensure there is no additional stress during the pandemic. The whole aim of a funding agency is to promote science and that should be their outcome: to foster the scientific community, they're not just a money lending or money giving operation.
- There needs to be flexibility within funding agencies as well to adapt to rapidly changing circumstances especially during a pandemic.

ECR responses from those who have either left or are planning to leave academia

ECRs who took the survey and indicated that they would like to be contacted for an in depth interview regarding their motivations to leave academia, were invited via an email. From 21 emails sent out, 5 ECRs responded and were interviewed specifically on their motivations and reasons vis-a-vis leaving or planning to leave academia.

Not being able to do desired work

- One Assistant Professor mentioned that they could not do much computational work on their personal computer and that there is an excellent high-performance cluster of computers on campus. Unfortunately, the cluster was not open for external access, and this affected their research output and productivity and they were not able to complete the work they wished to do.
- Another ECR mentioned that they were planning to leave academia and join the industry. They mentioned that motivation is a major concern and the very basic essence of scientific research. "When talking about research, one talks about the advancement of knowledge but amidst the rush to publish papers in order to stay relevant, it is hard to find meaning and quality in the work", the ECR mentioned.
- Another ECR mentioned that most people are trying to leave academia, they are waiting for just one more manuscript publication, or some genuine reason such as finances, or career progression, or the structure of the academy is a concern for them. The ECR mentioned

that: "academics actually have to sacrifice the very essence of virtue of their research in order to just keep on moving in a career". COVID-19 became the priority for research in the biological sciences and for research related to COVID-19, researchers had to fit their work into this field or come up with new research, which added to the stress of publishing.

- Most academics experience tremendous pressure to publish in order to maintain and continue a career in academia. If a researcher does not constantly publish, there is a worry that they will no longer matter. The 'publish or perish' model does not work for many academics. The number of publications rather than the impact factor publication is considered as central to an academic's professional life without consideration of the academic's skills and research abilities. It is an artificial system that is very subjective since the number of publications and publication timelines vary among fields and also depend on the questions that scientists are asking in their research.

Teaching Online

- An assistant professor mentioned that since they started teaching online, the institution has said that attendance is not compulsory for the students. So in a class of 56, they get 5 students. The lecture is recorded but feedback in a live class is very different and the lack of feedback and students in the class is challenging and demotivating.

Proposal / Funding Difficulties

- Funding agencies started proposals calling for COVID related research, only those researchers who have COVID-19 or such related proposals could apply for them.
- A researcher expressed that people at the central agency are a lot more helpful compared to the local level agencies. The funders at the local levels do not offer feedback and hinder improvement or merely state that there is something wrong with the proposal. If funding agencies cannot pay, then one cannot pay PhD students for six to seven months. "How can one be expected to stay in the job and get a PhD and not go for a lucrative career in the industry, which offers us like some Rs. 60,000 salary?" one ECR mentioned.

Appraisal / Salary Issues / Funding

- An assistant professor who had recently joined their institution said that they did not get an appraisal in December 2020. The appraisal delay was further blamed on employees as the tone of the university was that they could not publish sufficiently.
- Intramural grants were also not funded due to COVID-19 research, they were delayed, which resulted in additional stress. For ECR's, having a PhD student, and these limitations and delays in funding create a situation where they think they are not being fair to the PhD students and hindering their professional life.
- Institutes were advertising without actually funding, which was another reason for added stress. There was no external funding, the intramural funding was insufficient to set up a lab or do the kind of research that was the need of the hour.
- Most ECRs said that mentoring PhD students in these circumstances is difficult. Due to the publish or perish model within academia, there is almost no importance paid to the quality of the work or the academic journal that the researcher publishes in. Researchers mentioned that this leaves them feeling unsatisfied with their work and with academia in general.
- There is lack of funding, lack of networking opportunities, and as a whole COVID created a situation because the University was also not earning enough revenue. While some universities did not cut salaries, there was much pressure around it and long delays in salaries. Additionally, the work from home arrangement is not taken seriously which is an additional stress factor.

Over work

- For one ECR, who is a woman with two young children, it is very difficult to manage work due to daycares and schools being closed due to the pandemic. Caring for children while continuing a full-time job in academia involves a lot more commitment. It is difficult to manage grants, PhD students and research while handling household duties. "Managing time, especially for women, is difficult, even whilst husbands are supportive. The Indian scenario is based in such a way that you have to be involved in some kind of household activity. So getting that kind of 100% dedication for the purpose of research gets difficult, then one starts to consider alternate career options that are available right now." Multiple duties as professor, supervisor, administrator and researcher leads to over-work and a lack

of focus on research. “Maybe in the industry, it would be a different scenario”, mentioned the same ECR.

- One of the reasons that women from academia are moving to industry is because with the pandemic, while more jobs have opened up in the industry, with respect to academia, the employment opportunities have reduced. There is a lot of uncertainty due to the pandemic, so, a lot of women ECRs especially are looking for better paying employment opportunities outside of academia.
- “We are working Sunday, Saturday, the semester got stretched, and there was no mid semester break, you know, like, after a semester, you might get a break. So in essence, since last January, we’ve been having back to back. So there is no break at all. And the university creates such an ambience, you know that we are so great, we did not deduct your salaries, you should be working even harder.”, mentioned one researcher.
- There was the added pressure of having to learn online learning platforms such as Moodle almost overnight without much support from the university/institute where they worked, one ECR mentioned. This added to their work and other professional responsibilities.

Lack of stability / opportunities / restrictions

- ECR, especially women, mentioned that there are fewer opportunities for women and the lack of access to campus and resources and the restrictions that were imposed on researchers during the pandemic, put them at a disadvantage, and halted publications. They felt like they wasted a year and this set-back has hampered their position in academia.
- Age is another factor that is a barrier for applications and opportunities, at least two researchers mentioned that as they grow older, opportunities reduce within academia.
- There are certain fellowships in India only for researchers who have done their postdoc outside India and they are eligible. However, the researchers who have studied in India miss out on such opportunities due to being ineligible. The ECR mentioned that it is not possible for every researcher to study abroad and the conditions for applying for fellowships are not suitable for them.
- Most expressed worry about losing a year, because it affects their professional development which leads to a lot of uncertainty. For ECRs who were already disadvantaged due to their gender, or financial burdens or other forms of discrimination they face, they now have to

also deal with the uncertainty brought by the pandemic. All of these problems get compounded with the years.

Discussion

The purpose of the study was to understand the comprehensive effect of the COVID-19 pandemic on STEM researchers and stakeholders (suppliers and funders) across India. It was noted from the findings that certain antecedents significantly predicted STEM scientists' ability to continue research work, teaching, maintain productivity, and mental health during the pandemic. The study highlights the various challenges faced by students, early career researchers, and STEM scientists at various positions in their careers during the COVID-19 restrictions in India.

Participants having a doctoral or a postdoctoral degree

Impact on one's ability to continue research during COVID-19 (RQ1)

Specifically, for the individuals who had received a doctorate or a postdoctoral degree, it was observed that those having a poor mental health were faced with an increase in core research issues (like methodological challenges, difficulty in data collection and dissemination, on campus staff being able to work). Further, greater difficulty in receiving a grant/fellowship led to an increase in the disruption of procuring lab supplies (slow or compromised supply chains and associated higher costs), and higher digital literacy led to an increase in the number of working hours for professional development (skill development, online courses/webinars, workshops, etc.). Scientists have been unable to procure basic lab supplies like gloves, plastic tips for pipettes, and centrifuge tubes slowing down or halting research projects (Woolston, 2021). Among life science trainees based in wet labs it was found that they made use of e-learning software during the lockdown to expand their skills (like, learning a new programming language) has increased (Korbel & Stegle, 2020).

In terms of gender, it was observed that for both men and women, poor mental health led to an increase in core research issues. Additionally, men faced a greater difficulty in receiving a grant or fellowship leading to a disruption in obtaining lab supplies hence impacting their ability to continue research work.

Taking into account the qualitative responses to the survey questions, it supported the quantitative results suggesting that issues related to money and funding along with health, lack to lab, no access to software/hardware, lack of technical support, and absence of research participants were the major

methodological challenges faced by the researchers. Further, in terms of professional development individuals mentioned attending conferences and enrolling for courses.

Impact on one's ability to continue to teach during the COVID-19 pandemic (RQ2)

For those who supervised PhD students, a greater disruption in lab supplies led to a greater impact on their supervisory role, in turn impacting one's teaching duties. Women faced a disruption in procuring lab supplies, which affected their supervisory role and faced more difficulty in migrating to online teaching due to lower mental health. This suggests a significant impact of the pandemic on teaching duties of women as compared to men. This is in line with findings from surveys of STEM researchers in Australia. They reported increased challenges in student supervision due to the lack of face-to-face communications, and also reported increased challenges in student supervision due to the lack of face-to-face communications and those with teaching responsibilities had increased teaching workload due to online teaching thus, limiting their research capacity (EMCR Forum, 2020).

In terms of dominant caste groups, it was observed that being able to manage switching to remote working, better stability in internet connection to work remotely, and lesser disruption in lab supplies had a lower impact on one's supervisory role. A greater stability in internet connection to work remotely and a better mental health led to a lower difficulty migrating to online teaching. Due to an unequal sample distribution, any comparison between dominant and oppressed groups might be difficult to interpret.

Additionally, the qualitative results reported a decrease in interaction, money, health, and methodological challenges as the issues having a negative impact on one's teaching.

Impact on researcher's scientific productivity (RQ3)

Susceptibility to greater core research issues (like, difficulty in data collection, dissemination, methodological challenges) led to an adverse change in one's scientific productivity. A study had shown that many doctoral students and early-career researchers (ECRs) from the UK were experiencing a negative impact of the lockdown restrictions on their ability to collect data, discuss ideas and findings with colleagues, and disseminate their research findings (Byrom, 2020). Further,

the pandemic had a significant impact on the productivity of early and mid-career researchers in STEM fields in Australia (EMCR Forum, 2020).

While men's scientific productivity was affected by external reasons like, greater research dependency on interactions with human participants and more core research issues (difficulty in data collection, dissemination, methodological challenges), women's productivity was affected due to personal financial instability and low mental health during the pandemic.

For dominant caste groups, a higher dependency of working in a physical lab for their research, was one of the reasons leading to an adverse change in scientific productivity. Due to an unequal sample distribution, any comparison between dominant and oppressed groups might be difficult to interpret.

Evidence from interviews with ECRs echo some of these findings. Some of the issues that affected researchers' scientific productivity were uncertainty, loss of time due to COVID, decline in scientific output, lack of access to lab, money, mental stress, and change in research field.

Impact on mental health among STEM scientists (RQ4)

Finally, less difficulty in receiving grants, lower change in scientific productivity, more university and social support led to an increase in mental health among STEM researchers. Specifically, an adverse change in scientific productivity led to a lower mental health among researchers which is in line with the findings of an Australian national survey that found the pandemic had a significant impact on mental health and productivity of STEM scientists (EMCR Forum, 2020). In a study conducted by Ogilvie et al. (2020) graduate students' mentioned that they received more support from their advisors, professors, and peers in terms of physical and mental well-being (Ogilvie et al., 2020). On the other hand, it was found that researchers having lesser social support networks within and beyond academia tended to struggle with their mental well-being (Byrom, 2020).

For men, receiving greater university and social support predicted better mental health. For women, difficulty in receiving a grant or fellowship and adverse change in their scientific productivity predicted lower mental health while, receiving higher social support from family, relatives, and peers

led to a better mental health. These differences bring into light the differential needs and challenges among men and women.

It was also noted that dominant caste groups which received greater social support showed better mental health. Due to an unequal sample distribution, any comparison between dominant and oppressed groups might be difficult to interpret. In terms of the qualitative responses, researchers noted that family and household responsibilities, fear of losing job, money, health of self and family, and fear of COVID some of the reasons leading to increased stress during the pandemic.

Reasons for leaving academia (RQ5 & RQ9) and thinking about leaving academia (RQ6 & RQ8)

The section concerning researchers who had left academia and were thinking about leaving academia had a low sample size due to which quantitative inquiry did not lead to any reliable and conclusive results (RQs 5 and 6). Hence, qualitative analysis was conducted on the descriptive responses provided by survey participants for these sections and supplemented by qualitative evidence from interviews with a subsample of ECRs.

Many participants reported issues with money and funding, increased work pressure as well as work load, and retirement were some of the major reasons for leaving academia. Further, a few participants also reported bad work culture, bias towards women, lack of opportunities, loss of job, and child care responsibilities as other reasons for not continuing their work in academia.

Researchers who were thinking about leaving academia mentioned lack of funding, poor work culture, delay in receiving salary, lack of support, high work pressure and workload, job insecurity, and bureaucratic issues as major reasons for the same.

In line with the survey responses, in-depth interviews conducted with ECRs planning to leave or had left academia highlighted similar reasons (RQs 8 and 9). They reported being unable to perform and complete desired work due to the pandemic along with funding difficulties and delays in receiving salary. Further, it was also noted that the issues of teaching online, increased workload,

and lack of opportunities and stability were some additional motivators and reasons for leaving and thinking about leaving academia.

Differential impact of the pandemic among ECR's, Heads of Institutes, Suppliers and Funders (RQ7)

The survey respondents mentioned ECRs and doctoral students as the ones experiencing the most setbacks in terms of mental, scientific difficulties due to the pandemic. From interviews with HoIs, it was evident that the pandemic impacted scientists in different ways: lack of access to their research material and laboratories that delayed research, however, some scientists could return with precautionary measures. For the HoIs, managing personnel remotely and also on campus once restrictions were lifted were the main challenges of the pandemic. Scenario planning due to the uncertainty of the pandemic was the main challenge and new role that the HoIs had to take on. Managing administrative, supervisory, teaching, research and personnel management tasks were impacted due to the virtual mode of work and the time allotted for each also changed for the HoIs. Ensuring that extensions of grants, additional sources of funding, current funding timelines, and disbursement of salaries was managed during the pandemic was one of the key roles of the HoIs. Mental health of their staff and scientists within the institute and their own mental health was a challenge during the pandemic, even though a few institutes did have counselling support. Virtual Coordination of software, hardware, and other research based support for the scientists was one of the key roles taken up by the HoIs during the pandemic.

For the funding agencies interviewed, they mentioned that current research by the organizations they support was either paused and COVID-19 related research took priority. The organisations supported by the funders were unable to utilise the funds set aside for field work/lab based work due to lockdown restrictions, but other forms of virtual research still took place. Funders mentioned that committees and boards had to be consulted on the new challenges for funding timelines as presented by the changing nature of the pandemic. The funders interviewed funded organizations, institutes, and individual scientists and the research goals linked the funding were adapted according to the pandemic. In terms of deadline extensions, funders provided cost and no-cost extensions while also easing the timelines for deliverables required during the funding period. Funding agencies also supported virtual means of research dissemination including workshops, webinars, conferences

and research podcasts with their scientists. This also included virtual meetings with the organisations they support and regular newsletters on research findings. A suggestion that was highlighted during the interview, was that organizations and institutes across the research spectrum must have a succession plan and a scenario plan in place to ensure minimum disruptions within the organization's structure due to unforeseeable events.

The suppliers of scientific equipment reported a delay in supply of material and equipment owing to lockdown related restrictions on travel within the country and across national borders. Government mandates on manufacturing and supply of material that favour domestic production, especially during the pandemic, have impacted the suppliers negatively due to added levels of permissions and bureaucratic procedures. Payments for the transportation and delivery of scientific material and equipment were delayed since research institutes were shut due to the lockdown. There were no changes in the type of primary market or target group during the pandemic, and the suppliers moved to virtual means of business through their website and online portals for transactions. However, not everything can be smoothly managed via a virtual medium since equipment needs to be sampled by the scientists or a physical demonstration needs to be completed before an equipment is purchased.

Policy recommendations that arise from various challenges faced by scientists during the pandemic (RQ10)

There has been extensive research since the onset of the COVID-19 pandemic that focuses on its impact on the scientific community, as well as their productivity. A large number of these studies focused on the disproportionate impacts of the pandemic as well as associated lockdown restrictions on female and traditionally underrepresented scientists around the world. These studies have pointed squarely to a larger penalty imposed on female scientists as a result of gendered norms of caregiving, lack of equal opportunities, among others.

Troublingly, our study points towards a larger toll on the mental well-being of female early-career researchers (ECRs) in India. Our research focuses on ECRs, as they are at a career stage that is often characterised by job uncertainty, lack of new job opportunities, and a lack of funding (Lopez-Verges et al., 2021). Thus, that the impact of the pandemic is magnified on this particular sample of

researchers is evident across many fields and has been shown in other large-scale survey work both, during the early stages of the pandemic (Myers et al., 2020), as well as later on (Morin et al., 2021).

First, while there are several studies that find adverse impacts of the pandemic on mental health of scientists (Chan et al., 2020), there are very few that are able to link them to other stressors. For example, Doyle et al. (2021) finds that physician scientists in the United States reported distress on account of increased clinical demands and research delays. Our work suggests that mental health was substantially improved when universities provided support, or scientists had strong social support systems (in the form of relatives, friends, or family), and was also associated with fewer disruptions in research work.

Our finding on the importance of social support, particularly for female ECRs is echoed in work by the National Academy of Sciences (Committee on Investigating the Potential Impacts of COVID-19 on the Careers of Women in Academic Science, Engineering, and Medicine, 2021), which indicates that any social isolation that women face in this regard can be particularly damaging for their well-being and productivity.

Kelly (2021) finds a reduction in the time that female scientists are able to devote to research, which mirrors some of the qualitative research findings from our work. However, this means that they are less 'visible,' and therefore less likely to be quoted as experts in the media (Jones, 2020). Similarly, lack of access to campus facilities was also cited among a large share of scientists in Johnson et al. (2021) -- a finding that is aligned with interviews with heads of institutes / universities as well as other ECRs.

Gao et al. (2021) finds that a large number of scientists reported pivoting to COVID-19 research during the pandemic, and our stakeholder interviews confirmed that funders made changes to their strategies to focus on COVID-19. Although quantitative evidence from our study does not suggest that personal or household financial stability played a significant role in mental health concerns or scientific productivity in the sample, research from Australia (McGaughey et al., 2021) and Ireland (Shankar et al., 2021) found that increased career uncertainty and concomitant financial insecurity contributed to greater stress.

In addition to the above recommendations, we asked for participants for their suggestions as well. These are summarised below and more details can be found in Appendix C Table Group 2.
Grant management and other administrative duties should be minimised for scientists as it takes away from their research time. Furthermore, ECRs suggested that flexible working hours must be adopted by the institute for the researchers to work independently especially during a pandemic when remote working arrangements are the norm. In terms of funding opportunities, ECRs felt that these must be made widely available for the smaller research institutes in the country, and that funding must be disbursed on time from funding agencies.

Survey responses also suggested that institutions must have a better environment for growth opportunities, which takes into account researchers' mental health, work-life balance, and provides holistic support to the researchers, which has gained importance during the pandemic. They also recommended that institutions must increase job opportunities and prioritize giving learning opportunities to graduates since online education has unfavourably impacted certain courses and skill learning. Especially for women researchers, ECRs mentioned that there should be support in providing day-care, affordable childcare, transport, flexible working hours taking into account the gendered division of labour in the house. Women researchers with children or those who have older people at home have also expressed the need to have flexible working hours as it gets harder to have a work-life balance. The administration should be acquainted with the process of scientific research and there is a need for upskilling in the tech domain to ensure smoother communication and efficient processing of paperwork digitally. An increase in efficiency, especially in the tech domain, of the administration is needed for quick decision-making and to figure out plans in case of changes in the mode of education.

Furthermore, in order to ensure networking and interaction between researchers, there should be more online workshops, conferences, mentorship opportunities and advancement of training to connect with peers. Finally, survey respondents felt that institutions should extend funding, submission, grant deadlines taking into account lack of access to labs, delay in procuring equipment and reduce the pressure for researchers to keep publishing.

Implications

Along with providing a detailed understanding on the various challenges faced by researchers in the STEM community, the current study also illuminates the needs of these researchers (like, importance of social and university support) in order to increase their scientific productivity and improve mental health during the pandemic. Noting the impact of the pandemic on mental health of researchers, an important inference from the study is normalising talking about mental health and providing necessary resources to academics to improve their mental health and build coping resources.

The study has many policy implications, like the need for training and development of STEM scientists in the area of technological skills and digital literacy to provide opportunities for upskilling researchers/professors and being able to transition to hybrid/online working. Furthermore, a necessity to develop standard operating procedures (SOPs) across domains of teaching and research to alleviate losses in the future. Noting the impact of the pandemic on mental health of researchers, an important inference from the study is normalising talking about mental health and providing necessary resources to academics to improve mental hygiene. Finally, setting up reserve funds to provide funding opportunities to researchers in the case of any such future contingency.

Additionally, this research provides a groundwork into addressing the impact of the pandemic on more understudied groups in India like women and individuals belonging to the oppressed caste. Even though many studies have been conducted in countries like the USA and UK to understand the impact of the pandemic on researchers, especially women and different racial groups, not many studies have highlighted this difference in an Indian context. Finally, the research gives an idea of how the pandemic affected STEM researchers not only from the perspective of ECR's but also, from a frame of reference of other stakeholders like the funding agencies, suppliers of lab equipment, heads of institutes, and other stakeholders.

Some of the survey participants provided some recommendations to improve researchers' experience in academia and also increase scientific productivity. A reduction in grant management and administrative duties of researchers, availability of funding opportunities, flexibility in working hours, providing support, and growth opportunities were a few suggestions made by the participants. Additionally, increase in job opportunities and training along with extending submission

deadlines and increasing networking among researchers was also reported. Last, providing support especially, for women in terms of childcare and transport were highlighted.

Limitations

Although the current research provides valuable insights into the needs and challenges faced by STEM researchers in India, there are a few limitations of the study. First, the total sample size was less, suggesting that the results cannot be generalised to all the STEM scientists in India.

Second, due to the pandemic only digital tools were used to disseminate the survey, making it available to only a select group of individuals having access to a device, internet connection, and possibly belonging to an urban area. Finally, the study lacked equal representation of different caste groups and research disciplines due to which it was difficult to make a comparison between each group regarding the impact of the pandemic. In particular, the study was unable to comment on scientists or ECRs from oppressed caste groups, who may have faced differing challenges relative to dominant caste group scientists.

Future directions

Subsequent studies can include a larger sample so that generalizable results are obtained. Additionally, a more representative sample comprising equal participants from different gender, caste, religion, and discipline groups so that comparisons between these can be made. Further, a more inclusive data collection method for the underprivileged groups can be employed in order to have a more representative sample take part in the study.

Supplementary Analysis

Participants having a graduate or a postgraduate degree (i.e., not a PhD)

Descriptive statistics (see Appendix B, Table 8 & 9)

A total of 175 individuals identified as men, 134 individuals identified as women, and 2 individuals identified as non-binary/transgender. The sample reported to have a mean age of 29.34 years (SD= 8.26) and 177 of the total participants belonged to a dominant caste group (Brahmin, Kshatriya, Vaishya, and other upper castes) whereas, 55 participants belonged to an oppressed caste group (Scheduled Caste, Scheduled Tribe, Other Backward Class, and other lower castes).

Reliability and validity

Internal consistency reliability and CFA using MLR method of estimation was computed of the indices to evaluate their psychometric properties. Since, the data for all the indices was not normal (see Table 10, Appendix B), DWLS estimation was also used to evaluate the validity of the indices (see Table 11, Appendix B). For the dataset involving individuals who had completed their graduate or postgraduate degree (check Appendix B), it was noted that the digital literacy index (α= 0.90, robust CFI= 0.980), the core research issues index (α= 0.74, robust CFI= 0.986), university support index (α= 0.89, robust CFI= 0.818), social support index (α= 0.83, robust CFI= 0.787), and the mental health index (α= 0.76, robust CFI= 1.00) had a good internal consistency reliability and an adequate model fit[1] (Groskurth et al., preprint).

Table 12

Correlation matrix

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. Age										
2. People residing in household	-0.02									
3. People residing in household below 18yrs	.22**	.28**								
4. People residing in household above 60yrs	0.09	.69**	.42**							
5. Caregivers in household	-0.03	.72**	.32**	.89**						
6. Access to independent workspace	-0.03	0.02	-0.02	0.05	0.11					
7. Depend on lab	-0.01	0.01	-0.09	-0.01	0.03	0.07				
8. Human participants	0.02	0.07	0	0.07	0.08	0.01	.36**			
9. Remote working	0.08	-0.01	0.03	0.05	0.06	.42**	-0.14	0.1		
10. Stable internet connection	0.06	0.02	-0.02	0	0	.30**	0	0	.26**	
11. Disruption in supplies	-0.02	0.06	-0.02	0.05	0.08	-.16*	.49**	.23**	-.22**	-0.05
12. Core research issues-total	0.04	0.07	0	0.08	0.09	-0.12	.36**	.28**	-0.01	-0.06
13. Digital literacy-total	-0.09	0.03	-0.15	-0.03	0.02	.22**	.23**	0.06	-0.08	.25**
14. Difficulty receiving grant	-0.05	0.14	-0.02	0.08	0.09	-0.16	.27**	0.1	-0.13	-0.13
15. Personal financial stability	-0.01	-0.06	-0.13	-0.1	-0.11	-0.15	0.14	0.14	-0.07	0.04
16. Household financial stability	-0.03	-0.03	-.17*	-0.07	-0.05	-0.03	.21*	0.12	-0.1	-0.13
17. Scientific productivity	-0.07	0.01	-.17*	-0.14	-0.07	-0.04	.18*	0.13	0.03	-0.02

18. University support-total	-0.06	0.07	0.07	.26**	.26**	.26**	-0.06	0.01	0.13	0.16
19. Social support-total	-0.09	.17*	-0.09	-0.01	0.09	.24**	0.06	-0.13	-0.06	.22*
20. Mental health-total	0	0.07	0.03	0.06	0.02	.26**	0	-0.07	.17*	.24**
21. Stress	0.02	-0.02	-0.05	0.05	0	-0.04	0.06	0.06	-0.11	0.08

Variable	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
11. Disruption in supplies										
12. Core research issues-total	.46**									
13. Digital literacy-total	0.12	-0.04								
14. Difficulty receiving grant	.41**	.35**	-0.08							
15. Personal financial stability	.28**	.37**	.20*	.52**						
16. Household financial stability	.16*	.41**	0.14	.39**	.66**					
17. Scientific productivity	.21*	.36**	.20*	.31**	.35**	.31**				
18. University support-total	0.02	0.03	-0.03	-0.03	-0.17	-.19*	-0.01			
19. Social support-total	0.14	0.01	.34**	0.14	0.16	0.08	.22**	.35**		
20. Mental health-total	-0.09	-0.08	-0.1	-0.04	-.21*	-.31**	-0.17	.40**	.21**	
21. Stress	.17*	.22*	.24**	0.09	.35**	.26**	.21*	0.09	.14*	-.21**

Note. * indicates $p < .05$. ** indicates $p < .01$.

Regression analysis

Based on significant correlations between variables (see Table 12), multiple regression models were computed using pairwise deletion (lavaan; Rosseel, 2012) to answer each of the above-mentioned research questions (see Table 13). Additionally, regression analysis was also performed on disaggregated datasets based on gender (men and women) and caste (dominant and oppressed caste). Additionally, a post hoc power analysis using G*Power (Faul et al., 2009) was computed for all the models having at least one significant predictor. It was observed that the models had a high power ranging from 0.99- 1.00 (α= 0.05) for the differing effect size, sample size, and number of predictors for each model.

The results showed that a greater difficulty in receiving a grant (β = 0.548, z = 2.082, p = 0.037) and a greater financial insecurity in the household (β = 0.848, z = 2.284, p = 0.022) significantly predicted higher core research issues. Further, greater difficulty in receiving a grant also predicted a higher description in lab supplies (β = 0.375, z = 3.569, p = 0.00). It was also observed that an adverse change in scientific productivity was predicted by higher core research issues (β = 0.080, z = 2.835, p = 0.005) and a greater support from the university predicted a better mental health (β = 0.084, z = 2.628, p = 0.009).

Among men, it was found that household financial instability significantly predicted core research issues (β = 0.987, z = 2.014, p = 0.044) and core research issues predicted an adverse change in scientific productivity (β = 0.115, z = 2.605, p = 0.009). Furthermore, it was noted that a stable internet connection to work remotely (β = 0.677, z = 2.083, p = 0.037) and a greater support from the university (β = 0.097, z = 2.093, p = 0.036) predicted a better mental health among men.

For women, a difficulty receiving a grant significantly predicted a greater disruption in lab supplies (β = 0.444, z = 2.958, p = 0.003) and, a lower disruption in lab supplies predicted a greater change in one's scientific productivity (β = -0.282, z = -2.078, p = 0.038). Additionally, greater difficulty in receiving a grant predicted an adverse change in scientific productivity among women (β = 0.374, z = 2.187, p = 0.029).

Greater household financial insecurity predicted more core research issues (β = 0.998, z = 2.309, p = 0.021) among the dominant caste. Further, greater difficulty in receiving a grant also predicted a

higher disruption in lab supplies (β = 0.454, z = 2.688, p = 0.007). It was also observed that access to an independent workspace to work from home (β = 0.941, z = 2.625, p = 0.009) and greater support received from the university (β = 0.125, z = 3.126, p = 0.002) significantly predicted better mental health for the dominant caste groups.

Table 13

Multiple Regression model estimates

Research Question	Full Sample		Men		Women		Dominant caste	
	N	R^2	*N*	R^2	*N*	R^2	*N*	R^2
RQ1- What impacts the ability to continue one's research during the COVID-19 pandemic?-Core research issues	251	0.230	146	0.280	101	0.117	164	0.207
RQ1- What impacts the ability to continue one's research during the COVID-19 pandemic?-Logistic issues (Disruption in supply)	261	0.201	148	0.176	109	0.222	172	0.198
RQ3- What impacts researcher's scientific productivity during the COVID-19 pandemic?	262	0.246	149	0.377	109	0.268	173	0.207
RQ4- What impacts mental health among STEM scientists during the COVID-19 pandemic?-Mental health	261	0.283	149	0.343	108	0.358	172	0.325
RQ4- What impacts mental health among STEM scientists during the COVID-19 pandemic?-Stress	262	0.170	149	0.256	109	0.199	173	0.245

Due to a small sample size for the oppressed caste groups (n =55), the correlations were spurious and unreliable to interpret.

For those who had left academia (N = 78) or were thinking about leaving academia (N= 25), due to a small sample size, deducible and reliable results cannot be obtained. Hence, qualitative data will be used as a way to gauge people's reasons for leaving or considering leaving academia.

Discussion

Impact on one's ability to continue research during COVID-19

For individuals who did not have a doctoral degree, the results showed that a greater difficulty in receiving a grant and a greater financial insecurity in the household led to an increase in core research issues. However, these difficulties did not lead to core research issues among the group of participants having a PhD. Along with that, a greater difficulty in receiving a grant also gave rise to a higher disruption in procuring lab supplies. A similar trend of difficulty receiving a grant leading to disruption in supplies was observed among participants having a PhD degree.

Among men, it was found that household financial instability increased core research issues while for women, difficulty receiving a grant significantly predicted a greater disruption in lab supplies. For individuals belonging to the dominant caste, it was noted that greater household financial insecurity led to more core research issues and greater difficulty in receiving a grant resulted in a higher disruption in lab supplies. It has been found that Hispanic and Black undergraduates were more likely than Asians and Whites to delay graduation due to restriction of access to resources and delay in projects (Report 1; Saw et al., 2020). A study has noted that PhD students in Brazil belonging to a minority ethnic group were more likely to be financially disadvantaged as compared to white students (Woolston, 2020).

Impact on researcher's scientific productivity

Adverse changes in scientific productivity were based on higher core research issues (like, difficulty in data collection, dissemination, methodological challenges). Similar tendency was also reported among the post-PhD group of participants. While for men greater core research issues led to an adverse change in scientific productivity, for women a greater difficulty in receiving a grant led to

an adverse change in productivity. Additionally, lower disruption in lab supplies resulted in a greater change in one's scientific productivity among women. A study noted that STEM female faculty and students reported facing more problems adapting to remote learning and technological issues as compared to their male colleagues and peers (Report 2; Saw et al, 2020).

Impact on mental health among STEM scientists

The good mental health of a STEM researcher was as a result of greater support received from the university. However, among researchers with a PhD/post-doctoral degree, apart from the importance of university support, difficulty receiving grant, social support, and change in productivity also affected their mental health. Furthermore, it was noted that a stable internet connection to work remotely and a greater support from the university predicted a better mental health among men.

It was also observed that access to an independent workspace to work from home and greater support received from the university significantly led to a better mental health for the dominant caste groups. An ethnographic study had noted that Brahmins and other upper castes dominate in science, medicine, engineering, and academic professions and culturally shape institutions based on their caste identities in India (Thomas, 2020).

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Appendix A

Survey: https://www.monkprayogshala.in/ia-survey

Interview Questionnaire: https://www.monkprayogshala.in/ia-survey

Appendix B

Table 1

Descriptive statistics of participants having a PhD/post-doctoral degree

Question	N	Mean	SD	Median	Minimum	Maximum
What is your age (in years)?	291	39.43	7.46	39	26	64
How many children do you have under the age of 6 years?	173	0.67	0.64	1	0	2
In what year did you receive your doctoral degree or complete your postdoctoral training?	275	2013.23	6.89	2015	1985	2021
How many people reside in your household?	269	3.83	1.47	4	0	10
How many people below 18 years of age reside in your household?	270	1	1.01	1	0	5
How many people above 60 years of age reside in your household?	269	0.92	0.96	1	0	5
If no, how many caregivers (apart from you) do you have in your household?	225	0.93	0.82	1	0	4
Since March 2020, when you have been working from home, to what extent did you have access to your own independent workspace? That is, a place where you could work from home with minimal disturbances.	222	7.47	2.8	7	1	11
To what extent does your research depend on working in a physical laboratory?	223	8.49	3.21	10	1	12*
To what extent does your research involve physical interaction with human participants?	222	7.11	3.45	7	1	12*
To what extent did you manage to switch to remote working in a virtual environment during the past year?	223	6.55	2.81	6	1	11
To what extent have you had a stable internet connection to work remotely?	222	8.17	2.29	9	1	11

Did you experience any disruption in procuring lab supplies (e.g., slow or compromised supply chains and associated higher costs)?	225	7.83	2.92	9	1	11
To what extent did you experience any difficulty in discussing research work with colleagues?	210	6.1	2.61	6	1	11
To what extent did the frequency of lab meetings change ?	209	5.23	2.61	6	1	11
To what extent did you experience difficulty in data collection?	207	7.52	2.94	8	1	11
To what extent did you experience difficulty in dissemination of research findings (e.g., via virtual conferences)?	208	5.99	2.87	6	1	11
To what extent did you have to change from working on your current research topic to COVID-19 related research?	208	4.36	3.31	4	1	11
On an average, was there a change in your number of working hours in terms of research time (e.g., grant writing, data collection, etc.) in the past year?	209	6.47	3.1	6	1	11
To what extent did you face any methodological challenges (e.g., access to laboratory, access to software, access to data, disruption in time-sensitive experiments, etc.) while conducting research during the pandemic?	209	7.59	2.66	8	1	11
To what extent did staff going home affect your research performance?	197	8.03	2.94	8	1	12*
How many staff did your lab operate with during the lockdown?	197	4.55	3.84	3	1	12*
To what extent were the staff staying on campus asked to leave?	196	8.68	3.48	10	1	12*
To what extent were the staff staying on campus able to continue their research work?	195	5.91	4.25	5	1	12*
To your best knowledge, were the students' PhD degrees delayed due to the lockdown?	196	8.97	2.81	10	1	12**

To your best knowledge, were postdoctoral scholars' training delayed due to the lockdown?	194	9.09	2.82	10	1	12**
On an average, was there a change in your number of working hours in terms of administration time (e.g., committee meetings, lab administration, etc.) in the past year?	171	6.5	2.98	6	1	11
On an average, was there a change in your number of working hours in terms of professional development (e.g., skill development, online courses/webinars, workshops, etc.) in the past year?	172	6.73	2.85	6	1	11
How many team members (other than yourself) do you have in your lab/research group?	143	9.78	26.09	6	1	300
To what extent are you able to do the following without help from a third party: - Access your email	165	9.85	2.76	11	1	11
To what extent are you able to do the following without help from a third party: - Access your bank account virtually	162	9.67	2.75	11	1	11
To what extent are you able to do the following without help from a third party: - Use digital technologies to work together with colleagues inside and outside your educational organisation.	162	9.59	2.36	11	1	11
To what extent are you able to do the following without help from a third party: - Video conference (e.g., while teaching/during a seminar)	163	9.64	2.34	11	1	11
To what extent are you able to do the following without help from a third party: - Share files (e.g., Dropbox, Google Drive/Classroom)	161	9.86	2.17	11	1	11
To what extent are you able to do the following without help from a third party: - Willing to learn about digital technology for work (e.g., new statistical software)	162	9.08	2.76	11	1	11
Did you face any difficulty in receiving a grant or fellowship?	164	8.18	3.79	9	1	12*

Since the lockdown in March 2020, to what extent has your personal financial stability been affected?	163	7.57	2.67	6	1	12**
Since the lockdown in March 2020, to what extent has your household's financial stability been affected?	164	7.4	2.58	6	1	12**
How many projects (local/international) have you been a part of as a PI/Co-PI?	158	4.06	24.76	2	0	312
How many projects (local/international) have you been a part of as other collaborator?	155	1.19	2.05	1	0	20
How many new collaborations have you been a part of since March 2020?	151	1.64	3.33	1	0	30
How many local/international conferences have you attended as a delegate?	157	2.1	3.35	1	0	20
How many local/international conferences have you attended as a panellist / speaker?	153	1.85	3.83	1	0	41
How many local/international conferences have you attended as an organizer?	154	0.73	1.63	0	0	15
How many papers have you peer-reviewed?	114	6.54	6.66	4	1	35
How many panels have you served on?	30	3.1	3	3	0	14
Since the lockdown in March 2020, please indicate the number of new articles you published as first/corresponding/lead author (not counting re-submitting the same article).	156	2.6	3.14	2	0	25
Since the lockdown in March 2020, please indicate the number of new articles you published as a co-author).	156	2.13	3.41	1	0	25
Since the lockdown in March 2020, please indicate the number of book chapters you authored/ co-authored.	151	0.81	1.45	0	0	8

Since the lockdown in March 2020, please indicate the number of books you authored/ co-authored.	151	0.23	0.8	0	0	7
How many research grants did you submit or resubmit, since March 2020?	90	2.57	1.95	2	0	12
To what extent do you think your scientific productivity has changed?	161	8.14	2.21	8	1	11
To what extent does your current job/work involve teaching duties?	155	6.81	3.5	7	1	11
Has your current teaching load changed since March 2020?	127	6.98	2.22	6	1	11
How difficult was it for you to migrate to online teaching (when classes were remotely held)?	126	6.4	2.59	6	1	11
To what extent did the pandemic affect your supervisory role?	89	6.75	3.24	8	1	11
Do you think the pandemic had a negative impact on your teaching?	128	5.97	3.36	7	1	11
On an average, was there a change in your number of working hours in terms of teaching time (e.g., preparation, grading) in the past year?	126	7.31	2.3	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - Advisor or Major Professor	129	5.83	3.22	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - University administrators	147	5.14	3.17	6	1	11
In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - Advisor or Major Professor	131	5.46	3.29	6	1	11

In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - University administrators	145	5.32	3.35	6	1	11
To what extent did your institute/university provide access to essential work resources to help continue your research work remotely during the lockdown?	146	6.25	3.52	6	1	11
To what extent did your institute provide flexibility in working hours?	143	7.52	3.32	8	1	11
To what extent did you receive training from your institute to learn new software, which can be operated remotely to continue your teaching or research work?	146	5.12	3.36	6	1	11
To what extent did your university provide loans/ monetary assistance for buying smartphones/ laptop/other hardware equipment (e.g., a microphone)?	144	3.26	3.03	1	1	11
Do you feel that you have received guidance regarding the financial implications of the shutdown to labs and funding?	146	3.1	3.22	1	1	11
To what extent did your university/institute support you at this time?	145	5.79	3.07	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - Peers	165	6.95	2.52	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - Partner, Family and Relatives	166	8.87	2.38	10	1	11
In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - Peers	161	5.61	3.35	6	1	11

In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - Partner, Family and Relatives	163	8.75	2.82	10	1	11
To what extent did your family/relatives support you at this time?	166	8.02	2.89	9	1	11
Please respond to the following with respect to your career in academia: - I feel optimistic about my career in academia	144	7.36	3.24	8	1	11
Please respond to the following with respect to your career in academia: - I feel that my job is highly secure	144	6.44	3.74	7	1	11
How would you rate your overall mental health?	165	7.57	2.44	8	1	11
Did the lockdown have an impact on your physical health? (e.g., sitting at the desk all day, lack of exercise)	165	5.02	2.66	5	1	11
Since the start of 2020, your work-life balance has:	165	5.04	2.66	5	1	11
To what extent have you felt stressed in the past year?	165	8.15	2.24	8	1	11
Overall, how happy has your life felt to you over the past month?	163	7.39	2.2	8	1	11
How likely are you going to pursue/ continue to pursue a STEM-related academic career? (thinking of leaving academia)	24	6.92	2.55	7	1	11
How likely are you going to pursue/ continue to pursue a STEM-related academic career? (left academia)	23	6.65	3.42	7	1	11

Note. *12= Not applicable to me, **12= I'm not sure

Table 2

Frequency distribution of participants having a PhD/post-doctoral degree

Question	Level	N	Frequency
Which gender do you identify as?	o Man (1)	297	150
	o Woman (2)		141
	o Non-Binary/Transgender (3)		0
	o Other (self-describe) (4)		0
	o Prefer Not to Say (5)		6
What is your marital status?	o Single (1)	298	68
	o Married (2)		221
	o Separated (3)		1
	o Divorced (4)		2
	o Widowed (5)		2
	o Other (self-describe) (6)		1
	o Prefer Not to Say (7)		3
Do you have children?	o Yes (1)	300	179
	o No (2)		121
What is your highest educational level?	o Doctorate (MD, PhD) (3)	300	162
	o Postdoctoral training (4)		138
From where have you completed your highest level of education?	o India (State University) (1)	292	55
	o India (Central University) (2)		33
	o India (Central Institute) (3)		69
	o India (Deemed University) (4)		34
	o India (Private University) (5)		8
	o University or Institute outside India (6)		93
What is your employment status?	o Student (1)	295	16
	o Employed (full-time) (2)		244

	o Employed (part-time) (3)		10
	o Self-employed (4)		5
	o Unemployed (5)		14
	o Retired (6)		5
	o Homemaker (7)		1
Which of the following best describes your current status?	o I am currently in academia (1)	295	202
	o I am currently in academia, but I am thinking about leaving academia (2)		40
	o I have left academia recently (after March 2020) (3)		18
	o I had left academia earlier (before March 2020) (4)		7
	o I have a PhD but never pursued a career in academia (5)		10
	o I had left academia (after March 2020) but I have returned to academia (6)		2
	o I had left academia (before March 2020) but I have returned to academia (7)		2
	o Other (self-describe) (8)		14
Where are you currently working?	o India (State University) (1)	250	21
	o India (Central University) (2)		26
	o India (Central Institute) (3)		84
	o India (Private Institute) (4)		53
	o India (R&D Institution) (5)		55
	o University or Institute outside India (6)		11
What is your current position?	o Teaching/Research Assistant (1)	251	6
	o Post Doc or equivalent (2)		47
	o Fellowship-sponsored scientist (e.g., Ramalingaswami Re-entry Fellowship)		25

	(3)		
	o Adjunct Professor or equivalent (4)		5
	o Assistant Professor or equivalent (5)		80
	o Associate Professor or equivalent (6)		44
	o Full Professor or equivalent (7)		17
	o Other (self-describe) (8)		27
In which primary sector are you currently working?	o Academic (1)	135	65
	o Governmental (2)		24
	o For-profit (3)		4
	o Not-for-profit (4)		18
	o NGO (5)		10
	o Industry (6)		9
	o Other (self-describe) (7)		5
What is the nature of your position?	o Contract-based (1)	271	109
	o Permanent (2)		135
	o Freelance (3)		8
	o Other (self-describe) (4)		19
What religion do you follow?	o Hinduism (1)	274	170
	o Islam (2)		11
	o Christianity (3)		10
	o Sikhism (4)		6
	o Buddhism (5)		5
	o Zoroastrianism (6)		0
	o Other (self-describe) (7)		29
	o Prefer Not to Say (8)		43
What caste do you belong to, broadly?	o General - Brahmin (1)	272	68
	o General - Kshatriya (2)		22

	o General - Vaishya (3)		12
	o General - Other dominant/upper castes (4)		47
	o Scheduled Caste (SC) (5)		10
	o Scheduled Tribe (ST) (6)		3
	o Other Backward Class (OBC) (7)		23
	o Other oppressed/lower caste (8)		0
	o None (9)		21
	o Prefer Not to Say (10)		57
	Other (self-describe) (11)		9
Are you the primary caregiver in your family?	o Yes (1)	269	154
	o No (2)		115
What is your primary discipline of research?	o Physics (1)	235	10
	o Chemistry (2)		4
	o Biology (3)		159
	o Mathematics (4)		7
	o Medicine (5)		21
	o Engineering (6)		12
	o Information Technology (7)		2
	o Humanities and Social Sciences (8)		5
	Other (self-describe) (9)		15
Do you own a personal laptop/desktop to conduct work from home?	o Yes (1)	223	187
	o University/ Institute provided one (2)		26
	o No, had to buy a new one (3)		9
	o No (4)		1
Are you currently a part of a lab/research group?	o Yes (1)	175	156
	o No (2)		19
If applicable, have you had to lay	o Yes, I have had to temporarily layoff	149	8

off/furlough any team members? Please select the best option that applies to you	a team member (1)		
	o Yes, I have had to permanently layoff a team member (2)		6
	o No, and team members are receiving their full salary and not using earned time or vacation time (3)		65
	o No, but team members are using up earned time and/or vacation time (4)		12
	o No, but team members are being paid less during this time (5)		8
	o Other (6)		5
	o Not applicable to me (7)		45
Since the lockdown in March 2020, on an average, with respect to the funding for your: - Projects	o Funding has increased (1)	164	4
	o Funding has decreased (2)		32
	o No change in funding (3)		48
	o I don't know (4)		18
	o Funding was discontinued (5)		12
	o Funding is delayed (6)		50
Since the lockdown in March 2020, on an average, with respect to the funding for your: - Lab	o Funding has increased (1)	159	6
	o Funding has decreased (2)		45
	o No change in funding (3)		35
	o I don't know (4)		25
	o Funding was discontinued (5)		14
	o Funding is delayed (6)		34
Since the lockdown in March 2020, on an average, with respect to the funding for your: - Department	o Funding has increased (1)	159	3
	o Funding has decreased (2)		24
	o No change in funding (3)		25
	o I don't know (4)		41
	o Funding was discontinued (5)		9
	o Funding is delayed (6)		27

Since the lockdown in March 2020, on an average, with respect to the funding for your: - Institute	o Funding has increased (1)	156	5
	o Funding has decreased (2)		46
	o No change in funding (3)		23
	o I don't know (4)		51
	o Funding was discontinued (5)		9
	o Funding is delayed (6)		22
Did you experience any impact of the pandemic on your payroll (on average)?	o Delay in receiving the full amount (1)	162	41
	o Did not receive the full amount (2)		13
	o Received the full amount on time (3)		93
	o Received a partial amount (4)		5
	o Other (self-describe) (5)		10
Has your fellowship or employment term changed because of COVID-19?	o It is uncertain at the moment (1)	164	27
	o It has stayed the same (2)		65
	o It has been shortened (3)		6
	o It has been extended (4)		7
	o Not applicable (5)		52
	o Other (self-describe) (6)		7
Since the lockdown in March 2020, please indicate if you have served as a peer-reviewer for journal articles?	o Yes (1)	164	118
	o No (2)		46
Since the lockdown in March 2020, please indicate if you have, served on a review panel for funding?	o Yes (1)	164	32
	o No (2)		132
Did you submit or resubmit a research grant?	o Yes (1)	161	90
	o No (2)		71
What are some ways you have been able to maintain productivity within the lab? (Choose all that apply)	☐ A few personnel are still going to lab (1)	75	75
	☐ Focus on data analysis or manuscript writing (2)	115	115

	☐ Collaboration with other labs (3)	52	52
	☐ Diversify the type of research you are working on (4)	51	51
	☐ Grant writing (5)	67	67
	☐ Interacting with collaborators (6)	55	55
	☐ Working on your lab website (7)	18	18
	☐ Other (Self describe) (8)	11	11
Have there been any unexpected silver linings to the COVID crisis? (Check all that apply)	☐ More time to write manuscripts (1)	83	83
	☐ More time to write grants (2)	39	39
	☐ More time with family (3)	93	93
	☐ Other (Self describe) (4)	23	23
What is the level at which you teach?	o Junior College/High School (1)	128	0
	o Undergraduate (2)		18
	o Postgraduate (3)		63
	o PhD and higher (4)		47
What is your current teaching load (instructional hours) in hours per week?	o Less than 3 hours (1)	128	49
	o 3 to 6 hours (2)		36
	o 6 to 12 hours (3)		20
	o More than 12 hours (4)		23
Do you supervise PhD students?	o Yes (1)	128	89
	o No (2)		39
Does your university have online library facilities?	o Yes (1)	145	99
	o No (2)		46
What has been the primary care format (for dependents) since March 2020?	o Splitting time with partner (1)	158	73
	o Care by relative (2)		20
	o Care by hired help (3)		15
	o Independently (4)		43

	o Other (5)		7
Did you receive any help for domestic work (e.g., house help, babysitter) in your household?	o Yes (1)	164	57
	o No (2)		72
	o Sometimes (3)		35
Do you experience any chronic health conditions?	o Yes (1)	168	45
	o No (2)		123
Do you have conditions that leave you immunocompromised?	o Yes (1)	167	18
	o No (2)		149
Have you ever tested positive for COVID-19?	o Yes (1)	168	37
	o No (2)		131
Have you received at least one dose of a COVID-19 vaccine?	o Yes (1)	167	155
	o No (2)		12
Did any members in your household test positive for COVID-19?	o Yes (1)	167	57
	o No (2)		110
Did you have to step in to help a family member/friend who suffered from COVID-19?	o Yes (1)	168	94
	o No (2)		74
Did you experience a temporary (or permanent) loss of research personnel who tested positive or displayed COVID-19 symptoms?	o Yes (1)	168	90
	o No (2)		78
Block 11: People who are thinking of leaving academia			
Since March 2020, have you transferred jobs?	o I have transferred from one academic/research institute to another (1)	23	1
	o I have transferred from an academic/research institute to industry (2)		1
	o I have transferred to a non-academic/research institute (3)		0
	o I am thinking about quitting academia (4)		17

	o I have quit academia (5)		1
	o I am thinking about retiring (6)		1
	o Other (self-describe) (7)		2
Have your long-term plans changed due to COVID-19?	o Yes (1)	24	20
	o No (2)		4
Do you think the pandemic has negatively affected your career prospects?	o Yes (1)	24	15
	o No (2)		6
	o Not sure (3)		3
Do you believe you've lost a job offer because of COVID-19?	o Yes (1)	24	7
	o No (2)		7
	o Unsure (3)		10
	o Other (self-describe) (4)		0
Block 10: People who have left academia			
Are you planning to return to academia?	o Yes (1)	23	6
	o No (2)		9
	o Maybe (3)		4
	o Unsure (99)		4
Since March 2020, have you transferred jobs?	o I have transferred from one academic/research institute to another (1)	22	1
	o I have transferred from an academic/research institute to industry (2)		2
	o I have transferred to a non-academic/research institute (3)		3
	o I am thinking about quitting academia (4)		2
	o I have quit academia (5)		10
	o I am thinking about retiring (6)		0
	o Other (self-describe) (7)		4

Have your long-term plans changed due to COVID-19?	o Yes (1)	24	18
	o No (2)		6
Do you think the pandemic has negatively affected your career prospects?	o Yes (1)	23	13
	o No (2)		4
	o Not sure (99)		6
Do you believe you've lost a job offer because of COVID-19?	o Yes (1)	23	9
	o No (2)		9
	o Unsure (99)		4
	o Other (self-describe) (4)		1

Table 3

Shapiro-Wilk test of normality

Indices	W	p-value
Digital Literacy	0.68	0.000
Core research issues	0.98	0.021
University support	0.99	0.354
Social support	0.98	0.014
Mental health	0.99	0.713

Table 4

One-factor Confirmatory Factor Analysis using Robust Maximum Likelihood (MLR) and Diagonally Weighted Least Squares (DWLS) methods

Indices	No. of items	N	Estimation	CFI	TLI	RMSEA	SRMR
Digital Literacy	6	160	MLR	0.827	0.712	0.343	0.062
			DWLS	1.00	1.042	0.00	0.062
Core research issues	8	133	MLR	0.846	0.784	0.129	0.078
			DWLS	0.988	0.983	0.043	0.077
University support	10	121	MLR	0.691	0.603	0.183	0.113
			DWLS	NA	NA	NA	NA
Social support	5	163	MLR	0.727	0.454	0.303	0.139
			DWLS	0.851	0.703	0.207	0.133
Mental health	4	168	MLR	1.00	1.004	0.00	0.022
			DWLS	NA	NA	NA	NA

Table 8

Descriptive statistics of participants having a graduate/postgraduate degree

Question	N	Mean	SD	Median	Minimum	Maximum
What is your age (in years)?	314	29.34	8.26	27	18	92
How many children do you have under the age of 6 years?	84	1.63	2.67	1	0	23
How many people reside in your household?	264	4.63	3.44	4	0	43
How many people below 18 years of age reside in your household?	266	2.12	4.63	1	0	55
How many people above 60 years of age reside in your household?	264	1.66	2.96	1	0	43
If no, how many caregivers (apart from you) do you have in your household?	242	1.91	2.42	2	0	33
Since March 2020, when you have been working from home, to what extent did you have access to your own independent workspace? That is, a place where you could work from home with minimal disturbances.	188	6.29	2.7	6	1	11
To what extent does your research depend on working in a physical laboratory?	188	7.87	3.04	8	1	12*
To what extent does your research involve physical interaction with human participants?	187	6.76	2.66	6	1	12*
To what extent did you manage to switch to remote working in a virtual environment during the past year?	187	6.03	2.69	6	1	11
To what extent have you had a stable internet connection to work remotely?	185	6.78	2.67	7	1	11
Did you experience any disruption in procuring lab supplies (e.g., slow or compromised supply chains and associated higher costs)?	189	6.38	2.93	6	1	11
To what extent did you experience any difficulty in discussing research work with colleagues?	179	6.12	2.4	6	1	11
To what extent did the frequency of lab meetings change ?	178	6.19	2.67	6	1	11
To what extent did you experience difficulty in data	178	6.85	2.49	6	1	11

collection?						
To what extent did you experience difficulty in dissemination of research findings (e.g., via virtual conferences)?	178	6	2.5	6	1	11
To what extent did you have to change from working on your current research topic to COVID-19 related research?	178	5.69	2.86	6	1	11
On an average, was there a change in your number of working hours in terms of research time (e.g., grant writing, data collection, etc.) in the past year?	177	6.47	2.53	6	1	11
To what extent did you face any methodological challenges (e.g., access to laboratory, access to software, access to data, disruption in time-sensitive experiments, etc.) while conducting research during the pandemic?	178	6.8	2.44	6	1	11
To what extent did staff going home affect your research performance?	167	7.31	2.63	7	1	12*
How many staff did your lab operate with during the lockdown?	167	5.84	3.23	6	1	12*
To what extent were the staff staying on campus asked to leave?	167	7.63	3.12	8	1	12*
To what extent were the staff staying on campus able to continue their research work?	166	6.48	3.23	6	1	12*
To your best knowledge, were the students' PhD degrees delayed due to the lockdown?	167	8.04	2.68	8	1	12**
To your best knowledge, were postdoctoral scholars' training delayed due to the lockdown?	166	8.28	2.85	8	1	12**
On an average, was there a change in your number of working hours in terms of administration time (e.g., committee meetings, lab administration, etc.) in the past year?	161	6.27	2.45	6	1	11
On an average, was there a change in your number of working hours in terms of professional development (e.g., skill development, online courses/webinars, workshops, etc.) in the past year?	160	6.76	2.45	7	1	11
How many team members (other than yourself) do you have in your lab/research group?	106	7.37	5.16	6	0	30
To what extent are you able to do the following	159	7.92	3.34	9	1	11

without help from a third party: - Access your email						
To what extent are you able to do the following without help from a third party: - Access your bank account virtually	154	7.79	3.3	8	1	11
To what extent are you able to do the following without help from a third party: - Use digital technologies to work together with colleagues inside and outside your educational organisation.	156	7.73	3.14	8.5	1	11
To what extent are you able to do the following without help from a third party: - Video conference (e.g., while teaching/during a seminar)	155	7.87	2.98	8	1	11
To what extent are you able to do the following without help from a third party: - Share files (e.g., Dropbox, Google Drive/Classroom)	154	8.06	2.99	9	1	11
To what extent are you able to do the following without help from a third party: - Willing to learn about digital technology for work (e.g., new statistical software)	154	8.05	2.89	9	1	11
Did you face any difficulty in receiving a grant or fellowship?	155	7.67	3.42	8	1	12*
Since the lockdown in March 2020, to what extent has your personal financial stability been affected?	157	7.59	2.66	7	1	12**
Since the lockdown in March 2020, to what extent has your household's financial stability been affected?	156	7.77	2.54	7	1	12**
How many projects (local/international) have you been a part of as a PI/Co-PI?	132	2.49	4.06	1.5	0	40
How many projects (local/international) have you been a part of as other collaborator?	134	2.25	2.23	2	0	8
How many new collaborations have you been a part of since March 2020?	133	2.17	2.1	2	0	10
How many local/international conferences have you attended as a delegate?	135	2.77	3.22	2	0	20
How many local/international conferences have you attended as a panellist / speaker?	132	2.02	2.18	1	0	7
How many local/international conferences have you attended as an organizer?	131	1.99	2.47	1	0	14

How many papers have you peer-reviewed?	54	4.83	4.92	4	1	25
How many panels have you served on?	46	3.91	2.49	4	0	12
Since the lockdown in March 2020, please indicate the number of new articles you published as first/corresponding/lead author (not counting re-submitting the same article).	130	2.55	3.69	1	0	23
Since the lockdown in March 2020, please indicate the number of new articles you published as a co-author).	130	2.62	5.32	1	0	56
Since the lockdown in March 2020, please indicate the number of book chapters you authored/ co-authored.	128	2.34	5.42	1	0	57
Since the lockdown in March 2020, please indicate the number of books you authored/ co-authored.	128	2.54	6.31	0.5	0	67
To what extent do you think your scientific productivity has changed?	150	7.41	2.27	7	1	11
To what extent does your current job/work involve teaching duties?	146	5.18	3.14	6	1	11
Has your current teaching load changed since March 2020?	98	2.26	0.93	2	1	4
How difficult was it for you to migrate to online teaching (when classes were remotely held)?	98	6.2	2.63	6	1	11
To what extent did the pandemic affect your supervisory role?	29	6.86	2.15	7	3	11
Do you think the pandemic had a negative impact on your teaching?	101	6.57	2.92	7	1	11
On an average, was there a change in your number of working hours in terms of teaching time (e.g., preparation, grading) in the past year?	100	6.48	2.06	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - Advisor or Major Professor	135	6.48	2.84	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - University administrators	136	6.05	2.97	6	1	11

In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - Advisor or Major Professor	137	6.13	3.02	6	1	11
In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - University administrators	135	6.34	3.24	6	1	11
To what extent did your institute/university provide access to essential work resources to help continue your research work remotely during the lockdown?	137	6.76	2.7	7	1	11
To what extent did your institute provide flexibility in working hours?	135	6.63	2.68	6	1	11
To what extent did you receive training from your institute to learn new software, which can be operated remotely to continue your teaching or research work?	136	5.82	2.93	6	1	11
To what extent did your university provide loans/ monetary assistance for buying smartphones/ laptop/other hardware equipment (e.g., a microphone)?	136	4.76	3.12	6	1	11
Do you feel that you have received guidance regarding the financial implications of the shutdown to labs and funding?	133	5.47	3.4	6	1	11
To what extent did your university/institute support you at this time?	135	6.1	2.71	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - Peers	207	6.69	2.83	6	1	11
In terms of your physical and mental health and well-being, how supported have you felt by the following people since March 2020? - Partner, Family and Relatives	207	7.81	2.7	8	1	11
In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - Peers	207	6.14	2.88	6	1	11
In terms of your material or economic well-being, how supported have you felt by the following people since March 2020? - Partner, Family and Relatives	205	7.84	2.68	8	1	11
To what extent did your family/relatives support you at this time?	208	7.4	2.94	7.5	1	11

Please respond to the following with respect to your career in academia: - I feel optimistic about my career in academia	136	6.31	3.47	6	1	11
Please respond to the following with respect to your career in academia: - I feel that my job is highly secure	135	5.79	3.38	6	1	11
How would you rate your overall mental health?	208	6.94	2.54	7	1	11
Did the lockdown have an impact on your physical health? (e.g., sitting at the desk all day, lack of exercise)	208	5.76	2.76	6	1	11
Since the start of 2020, your work-life balance has:	206	5.93	2.85	6	1	11
To what extent have you felt stressed in the past year?	206	7.21	2.49	7	1	11
Overall, how happy has your life felt to you over the past month?	207	6.78	2.54	7	1	11
How likely are you going to pursue/ continue to pursue a STEM-related academic career? (thinking of leaving academia)	25	5.84	2.81	6	1	10
How likely are you going to pursue/ continue to pursue a STEM-related academic career? (left academia)	78	4.82	3.29	5	1	11

Note. *12= Not applicable to me, **12= I'm not sure

Table 9

Frequency distribution of participants having a graduate/postgraduate degree

Question	Level	N	Frequency
Which gender do you identify as?	o Man (1)	315	175
	o Woman (2)		134
	o Non-Binary/Transgender (3)		2
	o Other (self-describe) (4)		0
	o Prefer Not to Say (5)		4
What is your marital status?	o Single (1)	315	206
	o Married (2)		98
	o Separated (3)		3
	o Divorced (4)		2
	o Widowed (5)		2
	o Other (self-describe) (6)		0
	o Prefer Not to Say (7)		4
Do you have children?	o Yes (1)	317	86
	o No (2)		231
What is your highest educational level?	o Graduation (BA, BSc, BMS, etc.) (1)	313	120
	o Post-graduation (MA, MSc, MMS, MBA, MPhil, etc.) (2)		193
From where have you completed your highest level of education?	o India (State University) (1)	300	114
	o India (Central University) (2)		61
	o India (Central Institute) (3)		43
	o India (Deemed University) (4)		31
	o India (Private University) (5)		41
	o University or Institute outside India (6)		10
What is your employment status?	o Student (1)	301	117

	o Employed (full-time) (2)		97
	o Employed (part-time) (3)		14
	o Self-employed (4)		23
	o Unemployed (5)		31
	o Retired (6)		6
	o Homemaker (7)		13
Which of the following best describes your current status?	o I am currently in academia (1)	303	151
	o I am currently in academia, but I am thinking about leaving academia (2)		29
	o I have left academia recently (after March 2020) (3)		27
	o I had left academia earlier (before March 2020) (4)		46
	o I have a PhD but never pursued a career in academia (5)		5
	o I had left academia (after March 2020) but I have returned to academia (6)		10
	o I had left academia (before March 2020) but I have returned to academia (7)		14
	o Other (self-describe) (8)		21
Where are you currently working?	o India (State University) (1)	239	58
	o India (Central University) (2)		30
	o India (Central Institute) (3)		58
	o India (Private Institute) (4)		50
	o India (R&D Institution) (5)		38
	o University or Institute outside India (6)		5
What is your current position?	o Teaching/Research Assistant (1)	234	82
	o Post Doc or equivalent (2)		16
	o Fellowship-sponsored scientist (e.g.,		19

	Ramalingaswami Re-entry Fellowship) (3)		
	o Adjunct Professor or equivalent (4)		4
	o Assistant Professor or equivalent (5)		14
	o Associate Professor or equivalent (6)		6
	o Full Professor or equivalent (7)		7
	o Other (self-describe) (8)		86
In which primary sector are you currently working?	o Academic (1)	179	54
	o Governmental (2)		34
	o For-profit (3)		16
	o Not-for-profit (4)		18
	o NGO (5)		29
	o Industry (6)		10
	o Other (self-describe) (7)		18
What is the nature of your position?	o Contract-based (1)	259	102
	o Permanent (2)		68
	o Freelance (3)		49
	o Other (self-describe) (4)		40
What religion do you follow?	o Hinduism (1)	271	162
	o Islam (2)		25
	o Christianity (3)		24
	o Sikhism (4)		14
	o Buddhism (5)		13
	o Zoroastrianism (6)		6
	o Other (self-describe) (7)		16
	o Prefer Not to Say (8)		11
What caste do you belong to, broadly?	o General - Brahmin (1)	267	69
	o General - Kshatriya (2)		34

	o General - Vaishya (3)		38
	o General - Other dominant/upper castes (4)		36
	o Scheduled Caste (SC) (5)		18
	o Scheduled Tribe (ST) (6)		4
	o Other Backward Class (OBC) (7)		24
	o Other oppressed/lower caste (8)		9
	o None (9)		13
	o Prefer Not to Say (10)		21
	Other (self-describe) (11)		1
Are you the primary caregiver in your family?	o Yes (1)	269	128
	o No (2)		141
What is your primary discipline of research?	o Physics (1)	196	26
	o Chemistry (2)		16
	o Biology (3)		88
	o Mathematics (4)		8
	o Medicine (5)		11
	o Engineering (6)		17
	o Information Technology (7)		8
	o Humanities and Social Sciences (8)		12
	Other (self-describe) (9)		10
Do you own a personal laptop/desktop to conduct work from home?	o Yes (1)	188	119
	o University/ Institute provided one (2)		21
	o No, had to buy a new one (3)		31
	o No (4)		17
Are you currently a part of a lab/research group?	o Yes (1)	165	113
	o No (2)		52
If applicable, have you had to lay off/furlough any team members? Please	o Yes, I have had to temporarily layoff a team member (1)	109	23

select the best option that applies to you	o Yes, I have had to permanently layoff a team member (2)		10
	o No, and team members are receiving their full salary and not using earned time or vacation time (3)		14
	o No, but team members are using up earned time and/or vacation time (4)		8
	o No, but team members are being paid less during this time (5)		10
	o Other (6)		4
	o Not applicable to me (7)		40
Since the lockdown in March 2020, on an average, with respect to the funding for your: - Projects	o Funding has increased (1)	153	18
	o Funding has decreased (2)		26
	o No change in funding (3)		24
	o I don't know (4)		43
	o Funding was discontinued (5)		17
	o Funding is delayed (6)		25
Since the lockdown in March 2020, on an average, with respect to the funding for your: - Lab	o Funding has increased (1)	142	11
	o Funding has decreased (2)		25
	o No change in funding (3)		26
	o I don't know (4)		39
	o Funding was discontinued (5)		18
	o Funding is delayed (6)		23
Since the lockdown in March 2020, on an average, with respect to the funding for your: - Department	o Funding has increased (1)	142	7
	o Funding has decreased (2)		29
	o No change in funding (3)		27
	o I don't know (4)		40
	o Funding was discontinued (5)		22
	o Funding is delayed (6)		17
Since the lockdown in March 2020, on an	o Funding has increased (1)	141	8

average, with respect to the funding for your: - Institute	o Funding has decreased (2)		30
	o No change in funding (3)		27
	o I don't know (4)		38
	o Funding was discontinued (5)		22
	o Funding is delayed (6)		15
Did you experience any impact of the pandemic on your payroll (on average)?	o Delay in receiving the full amount (1)	153	56
	o Did not receive the full amount (2)		24
	o Received the full amount on time (3)		49
	o Received a partial amount (4)		12
	o Other (self-describe) (5)		12
Has your fellowship or employment term changed because of COVID-19?	o It is uncertain at the moment (1)	158	33
	o It has stayed the same (2)		47
	o It has been shortened (3)		22
	o It has been extended (4)		18
	o Not applicable (5)		27
	o Other (self-describe) (6)		11
Since the lockdown in March 2020, please indicate if you have served as a peer-reviewer for journal articles?	o Yes (1)	155	57
	o No (2)		98
Since the lockdown in March 2020, please indicate if you have served on a review panel for funding?	o Yes (1)	153	47
	o No (2)		106
Did you submit or resubmit a research grant?	o Yes (1)	151	53
	o No (2)		98
What are some ways you have been able to maintain productivity within the lab? (Choose all that apply)	☐ A few personnel are still going to lab (1)	61	61
	☐ Focus on data analysis or manuscript writing (2)	73	73
	☐ Collaboration with other labs (3)	31	31
	☐ Diversify the type of research you	41	41

	are working on (4)		
	☐ Grant writing (5)	23	23
	☐ Interacting with collaborators (6)	29	29
	☐ Working on your lab website (7)	19	19
	☐ Other (Self describe) (8)	13	13
Have there been any unexpected silver linings to the COVID crisis? (Check all that apply)	☐ More time to write manuscripts (1)	62	62
	☐ More time to write grants (2)	37	37
	☐ More time with family (3)	74	74
	☐ Other (Self describe) (4)	25	25
What is the level at which you teach?	o Junior College/High School (1)	101	27
	o Undergraduate (2)		37
	o Postgraduate (3)		30
	o PhD and higher (4)		7
What is your current teaching load (instructional hours) in hours per week?	o Less than 3 hours (1)	98	25
	o 3 to 6 hours (2)		31
	o 6 to 12 hours (3)		34
	o More than 12 hours (4)		8
Do you supervise PhD students?	o Yes (1)	101	29
	o No (2)		72
Does your university have online library facilities?	o Yes (1)	129	70
	o No (2)		59
What has been the primary care format (for dependents) since March 2020?	o Splitting time with partner (1)	204	54
	o Care by relative (2)		56
	o Care by hired help (3)		25
	o Independently (4)		53
	o Other (5)		16
Did you receive any help for domestic	o Yes (1)	204	79

work (e.g., house help, babysitter) in your household?	o No (2)		100
	o Sometimes (3)		25
Do you experience any chronic health conditions?	o Yes (1)	209	70
	o No (2)		139
Do you have conditions that leave you immunocompromised?	o Yes (1)	207	52
	o No (2)		155
Have you ever tested positive for COVID-19?	o Yes (1)	208	83
	o No (2)		125
Have you received at least one dose of a COVID-19 vaccine?	o Yes (1)	207	157
	o No (2)		50
Did any members in your household test positive for COVID-19?	o Yes (1)	205	97
	o No (2)		108
Did you have to step in to help a family member/friend who suffered from COVID-19?	o Yes (1)	207	120
	o No (2)		87
Did you experience a temporary (or permanent) loss of research personnel who tested positive or displayed COVID-19 symptoms?	o Yes (1)	208	96
	o No (2)		112
Block 11: People who are thinking of leaving academia			
Since March 2020, have you transferred jobs?	o I have transferred from one academic/research institute to another (1)	25	6
	o I have transferred from an academic/research institute to industry (2)		2
	o I have transferred to a non-academic/research institute (3)		5
	o I am thinking about quitting academia (4)		9
	o I have quit academia (5)		2
	o I am thinking about retiring (6)		0

	o Other (self-describe) (7)		1
Have your long-term plans changed due to COVID-19?	o Yes (1)	25	15
	o No (2)		10
Do you think the pandemic has negatively affected your career prospects?	o Yes (1)	25	18
	o No (2)		4
	o Not sure (3)		3
Do you believe you've lost a job offer because of COVID-19?	o Yes (1)	25	13
	o No (2)		8
	o Unsure (3)		4
	o Other (self-describe) (4)		0
Block 10: People who have left academia			
Are you planning to return to academia?	o Yes (1)	80	13
	o No (2)		39
	o Maybe (3)		17
	o Unsure (99)		11
Since March 2020, have you transferred jobs?	o I have transferred from one academic/research institute to another (1)	81	7
	o I have transferred from an academic/research institute to industry (2)		10
	o I have transferred to a non-academic/research institute (3)		19
	o I am thinking about quitting academia (4)		8
	o I have quit academia (5)		25
	o I am thinking about retiring (6)		7
	o Other (self-describe) (7)		5
Have your long-term plans changed due to COVID-19?	o Yes (1)	82	46
	o No (2)		36

Do you think the pandemic has negatively affected your career prospects?	o Yes (1)	81	40
	o No (2)		22
	o Not sure (99)		19
Do you believe you've lost a job offer because of COVID-19?	o Yes (1)	80	30
	o No (2)		25
	o Unsure (99)		23
	o Other (self-describe) (4)		2

Table 10

Shapiro-Wilk test of normality

Indices	W	p-value
Digital Literacy	0.92	1.96E-07
Core research issues	0.98	0.002
University support	0.96	0.00075
Social support	0.98	0.002
Mental health	0.98	0.025

Table 11

One-factor Confirmatory Factor Analysis using Robust Maximum Likelihood (MLR) and Diagonally Weighted Least Squares (DWLS) methods

Indices	No. of items	N	Estimation	CFI	TLI	RMSEA	SRMR
Digital Literacy	6	149	MLR	0.98	0.967	0.086	0.039
			DWLS	1.00	1.013	0.00	0.038
Core research issues	4	176	MLR	0.986	0.957	0.076	0.032
			DWLS	1.00	1.022	0.00	0.032
University support	10	128	MLR	0.818	0.765	0.158	0.082
			DWLS	0.999	0.999	0.13	0.082
Social support	5	202	MLR	0.787	0.573	0.306	0.098
			DWLS	0.961	0.923	0.121	0.093
Mental health	3	205	MLR	1.00	1.00	0.00	0.00
			DWLS	1.00	1.00	0.00	0.00

Appendix C

Table Group 1

Qualitative analysis **of 6% of the survey** responses corresponding to each RQ.

RQ1.A- What impacts the ability to continue one's research during the COVID-19 pandemic?

Theme	No. of responses	Examples
Money/funding	5	*"Slowing of fellowship disbursement from funding agencies and home institute."* *"money"*
Health	2	*"Health is money"*
Wet lab work	3	*"Wetlab has been greatly hampered and so review work has been done more broadly."*
No access to lab/field sites	2	*"I could not work in my experimental lab during the last 1.5 years. We were told to go home and the lab remained shut down."*
No access to software/hardware	1	*"Some of the software that I use for R&D is restricted to campus computers. There was no way I could use the software while working from home."*
Challenges in results analysis	1	*"Problem faced in result analysis specially on statistical calculation"*
Pivot to virtual platform	1	*"We have to shift everything on virtual platform which is little bit difficult for biology student to work with computer"*
Lack of technical support	1	*"It was difficult to get technical support from the service people when instruments like genetic analysers don't work."*

Lack of research subjects/participants	1	*"During the lockdown, there was a sharp decline in the footfall of TB Patients at the DOTS Centre, due to which I had to face several issues while selecting the eligible participants."*
No changes	1	*"no changes"*

*21 blank responses not analysed.

RQ1.B- What impacts the ability to continue one's research during the COVID-19 pandemic?

Survey Question: Q27a- If none of the abovementioned criteria applies, describe changes in your professional development.

Theme	No. of responses	Examples
Money	4	[Respondents used the word 'money' in these responses]
Health	2	[Respondents used the word 'health' in these responses]
No	1	[Respondents used the word 'No' in these responses]
NA	2	[Respondents used the word 'NA' in these responses]
Attending conferences and courses	3	*"I was attending more conferences, webinars, and workshops through online mode."* *"I invested time in many online certificate courses"*
No extra time	1	*"There was no extra time for professional development, given the emergency need to develop online teaching material etc."*

	"Online classes as well as CME have led to Digital Saturation and it is difficult to focus while having a virtual conference."

*26 blank responses not analysed

RQ2- What impacts one's ability to continue to teach during the COVID-19 pandemic?

Survey Question: Q6a- Do you think the pandemic had a negative impact on your teaching? Please describe some of these issues, if applicable.

Theme	No. of responses	Examples
Decrease in interaction	3	*"Response of students and interaction decreased a lot."* *"Face-to-face interaction has always been my great source of learning and sharing scientific thoughts with others. In COVID-19 pandemic, due to lockdown the said interaction with my research colleagues, supervisors, lab mates reduced greatly which hampers my research activities."*
Money	3	[Respondents used the word 'money' in these responses]
Health	1	[Respondents used the word 'health' in these responses]
Methodological challenges	2	*"I am an effective user of the 'chalk and talk' method of teaching. My skills associated with this method as well as those associated with interpersonal communication in face-to-face classes could not be applied much in online teaching."*

*30 blank responses not analysed

RQ3- What impacts researcher's scientific productivity during the COVID-19 pandemic?

Survey Question: Q15- To what extent do you think your scientific productivity has changed? Please describe some issues, if applicable.

Theme	No. of responses	Examples
Uncertainty	1	*"low motivation, uncertainty"*
Loss of time due to lockdown	1	*"Time lost during the lockdown and resuming the experiment was taken quite bit of time"*
Scientific output declined	2	*"I have been able to generate less data and publish fewer papers as compared to the pre-2020 period."*
Lack of access to the lab	1	*"The major issue is the connectivity to the lab. We are totally packed in-home and worked remotely without any further guidance and resources."*
Money	3	[Respondents used the word 'money' in these responses]
Health	1	[Respondents used the word 'health' in these responses]
Additional time due to the lockdown	2	*"I have used this time to write up old datasets and encouraged my students to work on secondary data (since they were unable to generate new data for their planned projects). This meant that I was actually writing more than I typically have time for."*
Mental stress	1	*"Mental stress because life is not normal. restricted spaces."*
Change in research field	1	*"I had to transition my research from Tuberculosis to COVID for a while. It started as a transient gig but it has already consumed 6 months so far & I don't know when I'll be able to work back on TB Research!"*
NA	1	[Respondents used the word 'NA' in these responses]

*24 blank responses not analysed

RQ4- What impacts mental health among STEM scientists during the COVID-19 pandemic?

Survey Question: Q5a- To what extent have you felt stressed in the past year? Please explain some of the reasons for the increase in stress.

Theme	No. of responses	Examples
Family and household responsibilities	4	*" Since schools and daycares are not functioning, my 3 years old kid is at home but I have to go to the office for my job. Fortunately, my husband has a work from home option so he is managing my kid. But still, he will be busy with online office meetings. So we are not able to spend time with the kid and not able to engage the kid."* *"Worried for students. Worried about my children's mental health and education."*
Fear of losing work/jobs/career-related stress	5	*"Financial instability and insecurity of the jobs."* *"Not meeting grant deadlines - One grant is ending without me having met the grant objectives. "*
Money	5	*"Secondly, delay in funding disbursement changed me personally especially during my COVID-19 infection."*
Health (self and family)	3	*"Concern regarding health of parents"*
Fear of COVID-19	2	*"Due to rising COVID cases, fear of losing near ones. Fear of contracting virus "*
NA	2	

*22 blank responses not analysed

RQ5- What has an impact on a STEM scientist's decision to return to academia, who left academia during the COVID-19 pandemic?

Survey question: If you have quit academia then, what was the major reason?

Theme	No. of responses	Examples
Money/Funding	5	*"Money"* *"No pay for 6 months due to delays in grant release with no support from the institution to ensure the grant gets released."*
Retired	3	
Lost job	1	*"I lost my job in academia due to inadequate funding from the government funding agency."*
Lack of job/ research opportunity	2	*"No job opportunity"* *"The pandemic also shut doors to various available research opportunities."*
Lack of support	1	*"No support from family"*
Bias towards women	1	*"Inherent bias towards women for faculty positions while favouring male candidates without transparent hiring process."*
Personal growth	1	*"Better career prospects and personal growth."*
Work pressure/ work load	3	*"Too much work, too many research projects + online teaching, constantly on a computer with no time for personal work which started interfering with my health."*
Bad work culture	1	*"I got tired of the very bad work culture at my place."*
Child care responsibilities	2	*"Need for partial work-from-home options to balance childcare needs."*

Lack of growth	1	*"no growth."*
Uncertainty	1	*"Uncertainty of future positions."*
NA	1	

Note. Includes responses from 21 participants; some participants noted multiple reasons.

RQ6- What has an impact on a STEM scientist's plan to continue a career in STEM even if they are thinking about leaving academia?
Survey question: What is your major reason for thinking of leaving academia?

Theme	No. of responses	Examples
Lack of funding	4	*"Reduced funding"*
Poor work culture	3	*"Unfair professional assessment at workplace"*
Salary/Money	5	*"Not sure when salary for myself and the other research staff will be released"*
Bureaucratic issues	4	*"Unfair, hypocritical, opaque system."*
Lack of support	3	*"Lack of support from upper management"*
Work pressure/ work load	4	*"A lot of pressure"* *"Working on* a contract *is hampering too much. Working 35 hrs per* week is *too much."*
Job stability/security	3	*"Lack of job stability"*
Recruitment issues	4	*"No recruitment."*
Growth	2	*"Career development prospects"*
Health	1	
No respect	1	*"No respect for my work."*
Bad experience	1	*"Due to my poor PhD experience especially during the treatment I received in the lockdown time."*
Resources	1	*"Better medical facility and openness to work independently"*
Awaiting results	1	*"Preparing* for the civil *service examination. Results awaited"*
ok	1	
Nil	1	

Note. Includes responses from 22 participants; some participants noted multiple reasons.

Table Group 2

A. Doctoral and Postdoctoral group survey Responses

Survey Question: According to you, which group of people (graduate students, early career researchers, heads of institutes, professors, to name a few) within your research institute experienced the maximum setbacks (mental, physical, scientific) due to the pandemic?

Theme	No. of responses	Examples
ECR	86	*"All researchers (Scientists and students)."* *"I think this affected everyone at their own respective levels."* *"Early Career Researchers who were expected to perform as per their grant requirements had to encounter difficulties with respect to administrative, technical, and career progression."*
Doctoral Researchers	104	*"Graduate students suffered the most. They experienced the greatest stress and lost the most time. I spent a lot more time focussing on the mental health of my students that I did before 2020"* *"It was Ph.D. graduates who faced the problem of delaying their Ph.D.'s and group heads (supervisors) kind of worried about their project timelines"*
Post-Doctoral Researchers	10	*"postdocs experienced the maximum setback"* *"I think the scientists on fellowships ending in 2021-2022 are the most hard hit. They not only lost out on the research time to prove themselves but also the opportunity to apply and find suitable permanent positions."*
Head of Institute	1	
Faculty/employees	9	*"Some faculty also took a hit especially if they did not have good means to share home responsibilities."*
Other	10	*"Among those, women professionals with small kids were the worst hit as the daycare facilities also closed down."* *"Agricultural field and general research work greatly hampered Only COVID-19 related research progressed"*

**146 blank responses*

Q2: Please mention two changes that you would like to be made to the scientific framework within India to ensure better support and productivity.

Theme	No. of responses	Examples
Improved Internet Facility	2	*"Broader internet connectivity"*
Better Resources	2	*"More workshops in cutting edge technologies to train the researchers to meet the global standards."*
Better Autonomy	2	*"More autonomy to researchers. Change in institutional culture"*
Increased Collaborations	3	*"High intensive force to collaborate, interact and make changes not only for grant and funds, projects but also for publishing quality research work"*
Better Evaluation	6	*"Researchers must be evaluated in a dynamic way rather than just looking at the total of Impact Factor of the journals they have published in. A more robust method of evaluating the performance and granting rewards is surely needed, which should consider publications, citations, h-index, Altmetrics, contribution as reviewer and editor, etc. "*
Age Restrictions	5	*"Age restrictions removed specially for women"*
Better Virtual Workplace	6	*"Most institutes rely on physical management of administrative aspects. I suggest that digital workspace is strengthened"*
Equal Opportunities	6	*"Equal opportunities in the post-PhD career, Especially the postdoc training. India has several post-PhD options to carry out research. Some of them pay more in terms of fellowship than others. Some fellowships have research support and some of them don't. It is mentally so stressful to see similar experienced and similar capabilities persons working in the same laboratory environment with large pay-gaps. Sometimes even the double difference! 2. No long term support for the regular postdoc fellowships. Two years is not sufficient!"*

Inclusive Practices	7	*"Gender (women's marital status) and age limit based employment biases must change "* *"Appreciation for honesty and talent by the authorities (without any discrimination based on gender, birth-place, institutional affiliation, prejudiced perception or affinity). Rendering equal opportunity for all (through free and fair interaction and by creating a conducive environment to function so as to get one motivated to give his/her 100%)."*
Better Support from Institutes	34	*"The Institute must provide a healthy professional ecosystem to Early career researchers. They are scientifically exploited and are never appreciated for their work."* *"Small sustenance grants to support scientists during periods when they might not have external funding. Better childcare system at workplace."* *"Scientific staff should be sparingly burdened with clerical duties and tedious paperwork rather than allow them to perform scientific duties peacefully with timely release of funds and demanding just the appropriate amount of justification avoiding redundancy. Easing the procurement policies to hasten the purchase process to shrinking the overall timeline of our research needs to be seen on par with defence procurement. GeM procurements are tricky and not reliable in terms of the quality demanding reforms in log scale."*
Better Mental Health Support	11	*"Provide better mental health support to PhD students and Postdocs."* *"Everyone should understand that working in pandemic is stressful and should do their best to reduce stress, especially like in terms of money"*
Flexible working hours	23	*"Flexible work time and Independent work culture"* *"Rewarding quality and not the quantity of work. Increase the ease of doing science, by making administrative rules flexible; this includes flexible working hours"*
Better and more opportunities for funding	39	*"Funding agencies need to distribute their funds to not-so-famous institutes in a similar fashion as they do with the more glamorous ones (e.g. IITs, IISER, NISER, etc.). Their pool of*

		grant-reviewers need to be much more diverse to guard against certain bias/ prejudice held by a short pool of reviewers against particular research ideas"
		"Better and more consistent financial support for graduate students "

Q3 and Q4: What do you think must be/can be done to improve people's experience within academia?

Theme	No. of responses	Examples
Flexible working hours	5	*"Working hours can be flexible so that people can manage both work and home. (especially for women). 2) If some of the academic work can be done from home, then the work from home option can be implemented. 3) Some kind of action needs to be taken to resume the daycare facility."*
Increase in opportunities	3	*"more posts and opportunities for new scientists are needed. We have 2000 JRF (NET qualified) but not 2 Scientist posts a year. it's a shame to struggle again for a job after doing a Ph.D."*
Mentorship	2	*"Mentors need to be trained better to be able to retain and support people."*
Impartiality in decisions	2	*"Recruitment should be done impartially"*
Age Restrictions	3	*" If possible, try to remove age limits for jobs."*
Decrease administrative burdens	2	*"Decrease bureaucracy, smoother admin function (to process paperwork)"*
Better institutional support	11	*"The holy grail of research is doing logical thinking, being truthful about the findings, and having a clear vision. But I realised that the philosophy of "publish or perish" is so rampant in academia's subconscious that not even the COVID-19 could break this trance. Authorities, funding agencies, institute*

		heads, and scientific leaders should come together to steer the wheel in the right direction."
Funding	15	*"Better funding structures"*
Networking Opportunities	2	*"External mentorship and networking avenues, opportunities for advancement of training "*
Transparent hiring process	2	*"Fair and transparent hiring process (Not favouring people in their own network). Support women candidates equally as much as the male candidates Ensure the hiring committee has at least 30% representation from women. Have a town hall type meeting with all stakeholders (faculty, scientists, postdocs, research staff, grad students, masters students and undergraduates) to address their concerns to help work together. Most often there are only faculty meetings held which may not address the concerns of all the parties involved."*

B. Below PhD Survey Responses

Survey Question: According to you, which group of people (graduate students, early career researchers, heads of institutes, professors, to name a few) within your research institute experienced the maximum setbacks (mental, physical, scientific) due to the pandemic?

Theme	No. of responses	Examples
ECR	32	*"I believe COVID-19 impacts all the people including researchers"* *"Everyone faced a setback"* *"early-career researchers are affected mostly. Due to lockdown lab accessibility has been reduced. Working hours are strictly restricted by the administration. Though the mental setbacks are avoidable. The work progress has been stuck due to the guidelines provided by the administration and the graduate students from residential campuses face a lot more trouble as their movement has been restricted within the campus"*
Doctoral Researchers	45	*"In addition to this, the final year students have faced a lot of mental pressure in worrying about their completion of research, thesis submission in time, and getting a postdoc position."* *"Graduate students are unable to get proper jobs due to a lack of training"* *"Graduate students as they have funding for a limited period of 5 years. If they have to stay back they would have to stay and work without receiving any stipend. This is a mental, scientific physical (if they weren't able to work) and financial setbacks."* *"The researchers (Junior Research Fellow and Senior Research Fellow students) have faced the maximum setbacks due to the pandemic. Especially the experiment researchers have gone through a more tough time as they couldn't do any research during this pandemic. The lockdown period was the wastage of their valuable Ph.D. time"* *"Ph.D. students of the final year who were about to finish the fellowship period were affected most as most of them wanted to finish and submit their thesis on time"*
Post-Doctoral Researchers	6	*"Post-doctoral researchers"*

Professors	3	*"Professors, head of institute"* *"Professors and HODs faced more of a mental and scientific setback, with a detail in the research work and the possibility of getting scooped. And having to deal with the incoming of new COVID cases "*
Staff	1	*"Temporary staff"*
Money	25	[Respondents used the word 'money' in these responses]
Health	13	[Respondents used the word 'health' in these responses]

**181 blank responses*

Q2: Please mention two changes that you would like to be made to the scientific framework within India to ensure better support and productivity.

Theme	No. of responses	Examples
Age Limit	1	*"remove age limits in hiring."*
Conferences and Interactions	12	*"Physical Workshop, even if it is for a smaller number of participants to allow COVID Appropriate Behaviour. Online Workshops are useless."* *"Firstly, person to person contact and sharing ideas and findings with each other. "*
Deadline Extensions	3	*"Allow greater flexibility in utilization of the financial resources allocated to various institutes and universities so that they can change what they spend the allocated resources on. Establish grants for PhD on extension so that they could apply for them if necessary. Facilitate better communication within institutes/universities and between institutes/ universities."*
Fixed work contracts	3	*"fixed salary and fixed job project"*
Flexible working hours	3	*"Talk on mental well-being Ease of choosing working hours"*
Funding	20	*"The funding for research has to increase drastically. The research facility in India is so poor. The infrastructure of research institutes and universities should be reformed immediately. We don't have a scarcity of talent but they are not getting proper exposure. There should be an increase in the number of researchers in india. If we don't focus on research, we can't progress at all."* *"To ensure fellowships to the students regularly and the amount has to be increased. 2. Funds in basic sciences should be increased and projects related to this should be increased."*
Vaccination Drives	2	*"Institute/University wise vaccination drive for the staff is highly needed"*
Mental Health	2	*"Secondly, there should be "active" mental counselling helplines for all universities and research cells, so that students can communicate when needed."*
Methods and Equipment	3	*"Timely supply of laboratory essentials"*

Increase in number of labs and access	6	*"Scientific community has to be more sincere We have to made more labs"* *"Allowing lab work during lockdown (like alternate days) with appropriate precautions"*
Publication	2	*"Less stricter norms for publication and reduced fees (article publishing charges) for publications in most journals."*
Rigorous Evaluation	3	*"1. Unbiased evaluation of the submitted project. If any submitted project is rejected then there should be a complete reason for rejection so that the Principal Investigator can improve the proposal for further submission. "*
Technology	3	*"Focus on developing better scientific infrastructure to facilitate sudden changes in research strategies."*
Working Environment	11	*"Transparency in the financial management of scientific projects and Independent working environment with advanced equipment to meet the global research environment"* *"Provide better working spaces in the institute with a housing option and mess during the pandemic"*
Health	11	[Respondents used the word 'health' in these responses]
Money	22	[Respondents used the word 'money' in these responses]
Other	5	*"Educating the fraternity over working or being a lab monk is not glamorous! Besides it should not serve as a benchmark for existing and future generations of peers"* *"Keep the research site stable and the research time sufficient"*

**187 blanks in the responses*

Q3 and Q4: What do you think must be/can be done to improve people's experience within academia? (291 blanks in the responses)

Theme	No. of responses	Examples
Job Security	1	*"more job security"*
Opportunities	7	*"Increase the number of institutes providing jobs. Have various grants for individuals to apply for funding from. Improve quality of a research students' life by integrating a better work life balance."* *"transparency better access and opportunities more funding and diversity"*
Administration	1	*"More of teaching and less of administrative duties"*
Better Environment	3	*"Better environment to grow"*
Financial Support	6	*"permanent job and salary"*
Exposure	2	*"More exposure and active communication"*
Transparency	2	*"selections should be transparent payment and growth options should be competitive"*
Support	2	*"There needs to be a proper framework regarding the protection of people from down-times and halted growth in their careers, by making the changes quick and helping everyone adapt faster. There has to be a holistic support and a mentality of progress, overall"*