

Researchers on ice? How the COVID-19 pandemic has impacted Antarctic researchers

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Abstract: The COVID-19 pandemic and pandemic-related measures have impacted the lives and work-related activities of Antarctic researchers. To explore these impacts, we designed, piloted and disseminated an online survey in English, Russian, Spanish and Chinese in late 2020 and early 2021. The survey explored how the pandemic affected the productivity of Antarctic researchers, their career prospects and their mental wellbeing. Findings exposed patterns of inequities. For instance, of the 406 unique responses to the survey, women appeared to have been affected more adversely than men, especially in relation to mental health, and early-career researchers were disadvantaged more than their mid- or late-career colleagues. Overall, a third of the research participants reported at least one major negative impact from the pandemic on their mental health. Approximately half of the participants also mentioned that the COVID-19 pandemic had some positive effects, especially in terms of the advantages that working from home brought and opportunities to attend events, network or benefit from training workshops online. We conclude with a series of recommendations for science administrators and policymakers to mitigate the most serious adverse impacts of the pandemic on Antarctic research communities, with implications for other contexts where scientific activities are conducted under extreme circumstances.

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Introduction: Antarctic research and the COVID-19 pandemic

Antarctic researchers are familiar with isolation, confinement and extremeness (ICE), which go hand in hand with fieldwork in challenging polar environments (Leon *et al.* 2011, Sandal *et al.* 2006, Palinkas & Suedfeld 2021, Van Ombergen *et al.* 2021). Since March 2020,

isolation and remoteness have become defining characteristics for much of the world, in academia and beyond, as a result of lockdowns and quarantine during the COVID-19 pandemic (Saltzman *et al.* 2020). Isolation has been identified as a significant stressor during the pandemic, especially for children and adolescents (Loades *et al.* 2020, Smith & Lim 2020) and older people (Brooke & Jackson 2020, Sepúlveda-Loyola *et al.* 2020).

Antarctic research does not operate in a vacuum. Science is a *raison d'être* of the Antarctic Treaty System, the collective consensus-based governance regime in place for the area south of 60° Southern Latitude and the currency of Antarctic diplomacy (Haward *et al.* 2006, Hemmings 2012, Elzinga 2017). Antarctic research serves an important geopolitical function as evidence of substantial Antarctic research activity is a requirement for signatory parties of the Antarctic Treaty to qualify for decision-making rights within the Antarctic Treaty System (Molenaar 2021), in accordance with Article IX of the 1959 Antarctic Treaty. However, this geopolitical role does not protect Antarctic research from challenges related to the broader commercialization of science (Irzik 2007, Biddle 2011), which accentuates broader inequities. These inequities can express themselves in job insecurity and a growing workforce of academics on casual short-term contracts, referred to as the 'academic precariat' (Ivancheva 2015). A significant body of scholarship has been dedicated to discussing the causes for and implications of precarity in academia (Pérez & Montoya 2018, Loher *et al.* 2019), which appears to be gendered (Steinþórsdóttir *et al.* 2019, Rosa & Clavero 2021) and has also been adversely affected by the COVID-19 pandemic (Kınıkoğlu & Can 2021).

The effects of such inequities and structural challenges are wide ranging in academic research cultures where the 'ideal' worker is an unencumbered white male whose private life does not impinge on his availability and commitment to the organization (Pullen *et al.* 2017). A primary concern for feminist scholars is that academic research cultures are constructed as meritocratic and employees are promised that 'talent, hard work and commitment will be identified and rewarded' (Morley 2014). For instance, Nash & Churchill (2020) argue that even though women remain the primary caregivers, they are continually judged in 'modalities of academic masculinity' in which research success is premised on a strong career drive and the prioritization of organizational commitments over relational ties to children, parents and other family members (Ivancheva *et al.* 2019). This brand of 'careerist masculinity' became more visible during the pandemic when institutions instructed staff to work remotely (O'Connor *et al.* 2015).

In addition, academic masculinity is accentuated as a result of an unequal academic service workload, which might lead to reduced academic productivity for some more than others. Systemic issues around gender inequity in academia are well understood and have been reported to exist around the world (Larivière *et al.* 2013, European Commission 2019, Huang *et al.* 2020, Woolston 2021). Furthermore, women academics reportedly often shoulder more than their fair share of academic service and administrative activities, such as on committees, curricula developments, student advising

or pastoral care responsibilities, which do not serve to elevate their research profile (Guarino & Borden 2017, Huang *et al.* 2020, Woolston 2020, Llorens *et al.* 2021). When many universities, in response to lockdowns and various other government restrictions, shifted their teaching online, women took on a greater amount of online teaching and mentoring (Richardson 2020). In the meritocracy that is academia, a focus on service is often disadvantageous to career progression. For women, this is often further adversely affected by imposter syndrome, which is another example of how women's supposed 'lack of confidence' has been pathologized as a way to mask structural oppression (Laux 2018, Edwards 2019, Taylor & Breeze 2020), and such systemic problems have been postulated as potentially causing women to decide to leave research or seeking careers where they feel more supported in times of hardship (Cidlinká 2019, Pruitt *et al.* 2021).

In fact, pandemics are not always even-handed, and neither is academia (Greely 2020). Institutional structures across different academic disciplines demonstrate persistent patterns of disadvantaging women, some ethnicities, people with caring responsibilities, people in lower-income countries and people without pre-existing networks in their field (Wold & Wennerås 1997, Mainguy *et al.* 2005, Wang & Degol 2017, Scholefield 2021). Although the consequences of COVID-19 are still emerging, existing data suggest that inherent existing inequities are compounded by the unequal impacts of disasters across societies (Cushman 2020, Myers *et al.* 2020, Oleschuk 2020, Camerlink *et al.* 2021, Kappel *et al.* 2021).

It is important to keep the academy's structural inequities, including academic precarity, in mind when examining the consequences of the COVID-19 pandemic on Antarctic research since the disease first emerged in late 2019 (Gray *et al.* 2020, Greely 2020, Khazanchi *et al.* 2020, Lorenzo & Drazich 2021). The disproportionate impacts it caused on societies and individuals around the world extend to researchers in general and Antarctic researchers specifically, given Antarctica's special geographical and political attributes.

For Antarctic researchers - defined as scholars whose research focuses on the Southern Ocean or the Antarctic continent¹ - the COVID-19 pandemic has amplified stressors that are latent with Antarctic research communities. This especially applies to those researchers who undertake fieldwork in Antarctica, which is an ICE environment (Palinkas 2003). Working in ICE environments entails specific psychological and physiological challenges, a detailed discussion of which is beyond the scope of the current article (for an

¹As such, the impacts of COVID-19 on Antarctic Gateway Cities such as Punta Arenas (Águila *et al.* 2020) would not typically enter into this study.

overview, see Palinkas & Suedfeld 2021), which were aggravated by the pandemic (Frame & Hemmings 2020, Hughes & Convey 2020, Tortello *et al.* 2021). Some of the key features of ICE environments include isolation, confined living quarters on stations and vessels, limited opportunities for privacy and little separation between work and leisure. The extreme environment also poses a number of physical challenges including disturbed sleep, mood and coping capacity (Van Ombergen *et al.* 2021). The COVID-19 pandemic has brought these stressors into everyday life for a global population, in addition to a range of other psychological impacts on mental health (Prati & Mancini 2021, Serafini *et al.* 2020), as well as broader health challenges (Iqbal *et al.* 2021). Stressors are here understood as events that cause strain or pressure because they limit, restrain or impede scientific research (Palinkas & Suedfeld 2021).

Antarctica is the only permanently uninhabited continent, making long-haul travel virtually impossible for any on-site research and involving scientists, technicians and other support staff. Indeed, a 2020 study showed that field scientists reported the largest drop in research time of a 30–40% decrease (Myers *et al.* 2020). An informal survey of Council of Managers of National Antarctic Programs (COMNAP) members revealed that only a third of the planned science activities were supported in the 2020/2021 Antarctic season (COMNAP 2021). Logistics support was reduced to ~40% of the planned activity, and at least four National Antarctic Programmes (NAPs) - the various public or public-private entities that manage national Antarctic activities - halted all of their Antarctic operations in the 2020/2021 season (COMNAP 2021). NAPs also deployed less than a third of the expeditioners they would normally send to the Antarctic over the summer season (COMNAP 2021). Antarctic research is no exception.

To our knowledge, the effects of the pandemic on Antarctic researchers - across different disciplines, nationalities, career levels and other demographics - has not yet been explored. To address this knowledge gap, Daniela Liggett assembled an international team of 35 Antarctic researchers from over 10 disciplines across the humanities, social sciences and physical sciences, who self-organized into six working groups to examine how COVID-19 has impacted human engagement with the Antarctic in terms of tourism, governance and science, from multiple scientific perspectives. In this article, our focus is specifically on the work of one of these groups, namely the one investigating the impact of the pandemic on scientific research and researchers.

In the forthcoming sections, we will discuss the study's methodology and results. Here, we focus on the links between the impacts of the pandemic as they intersect with the demographic characteristics of the study

participants (e.g. gender, career stage and field of research) before comparing our findings to those from other studies and positioning them against institutional structures and existing inequities in the academy that we have outlined above. We conclude with recommendations for science administrators and policymakers to mitigate the most serious adverse impacts of the pandemic on the Antarctic research community.

Methods

This study investigated three key research questions:

- What are the impacts of COVID-19 on Antarctic research and researchers?
- How do the impacts vary according to demographics such as career stage, gender, nationality and nature of their research? Who are the most vulnerable researchers?
- What kind of assistance is most valued by researchers to reduce the severity of the pandemic's impacts?

Our exploratory survey contained 43 questions, derived from existing surveys such as the Montreal Behavioural Medicine Centre's international series of surveys undertaken as part of the iCARE (International COVID-19 Awareness and Responses Evaluation) study (Bacon *et al.* 2021) and the UK Marine Science COVID-19 Working Group Impact Survey (NOCA 2020). The survey was distributed in September 2020 and was open for 10 weeks. To ensure research participants could provide informed consent prior to participation, an electronic consent form was positioned at the start of the survey. A skip logic ensured that any participant who did not provide informed consent did not complete the survey. This study was approved by the Human Ethics Committee of the University of Canterbury.

Participants were recruited mainly through direct email to members of relevant Antarctic networks and associations (e.g. the Scientific Committee on Antarctic Research (SCAR), the Association of Polar Early Career Researchers (APECS), COMNAP and the European Polar Board (EPB), amongst others). The email that was distributed to relevant groups contained a link to the survey and an open invitation to participate. We also recruited participants via the social media feeds of individual researchers involved in this work as well as via the social media feeds of some of the aforementioned organizations, in particular SCAR and APECS. Potential participants were directed via weblink to an information sheet that provided detail on the background, rationale and anticipated outcomes of the project. Participants were self-selected and do not necessarily represent of the entire population of Antarctic researchers.

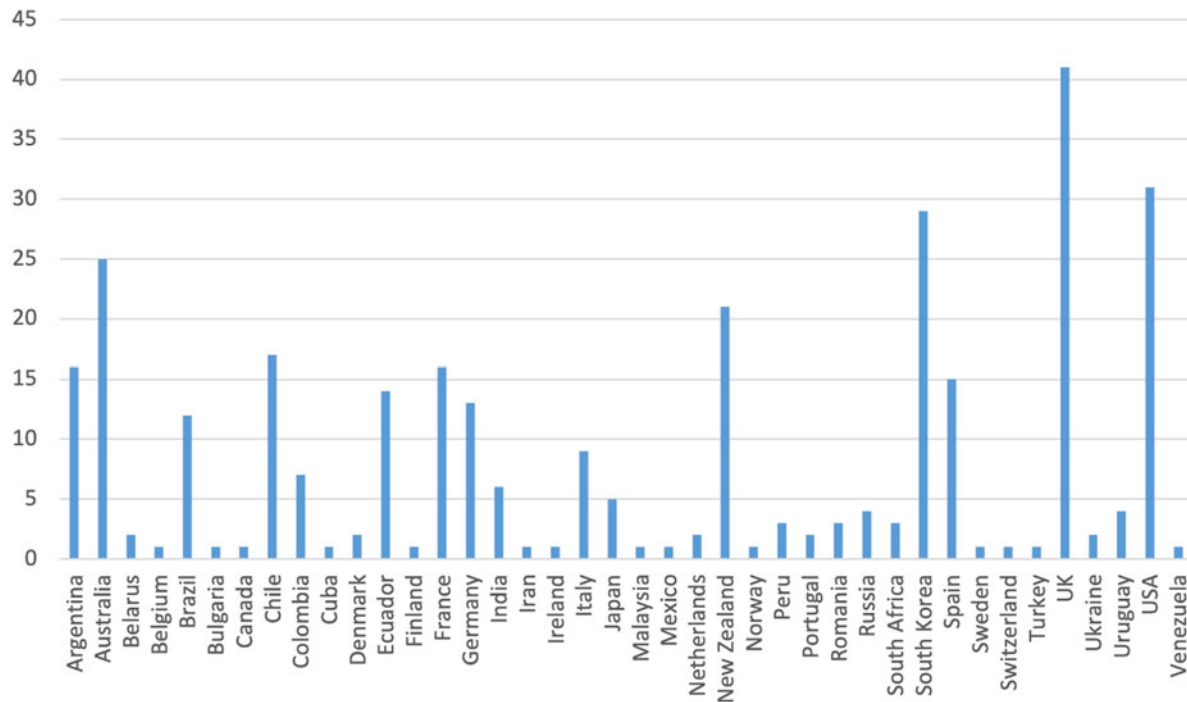


Fig. 1. Nationalities of research participants ($n = 318$).

We received 474 survey responses, of which 406 were unique and considered usable for data analysis, which was restricted to those participants who provided complete survey data by responding to at least 10% of the survey questions. The demographic breakdown of the research participants is summarized in [Fig. 1](#) & [Table I](#). Most responses were in English, with two in Mandarin, five in Russian and 24 in Spanish. Despite a multi-continental research team and wide engagement with projects and national programmes across many countries, 37% of participants originated from the USA, the UK, New Zealand or Australia. It is probable that this is related to the fact that these four states have a larger number of Antarctic researchers and long-standing and influential Antarctic research programmes.

The survey consisted of closed and open-ended questions. This format allowed participants to provide unrestricted comments rather than selecting from only predetermined choices. Closed questions were used to gather socio-demographic data (e.g. gender, age, nationality, occupation and education) and included Likert-scale questions to collect information about the impact of the pandemic on the participants' productivity, career and mental health. Open-ended questions were used to gather additional contextual data and examples about how certain aspects of the participants' lives were affected by the pandemic and what actions might be taken by science administrators, employers and others to mitigate some of the adverse impacts of the pandemic.

All questions were designed from the relevant literature (e.g. [Evanoff *et al.* 2020](#), [Jewell *et al.* 2020](#), [White & Van Der Boor 2020](#)), and participants could decline to answer any question.

Survey responses were collated initially in .csv format in *Microsoft Excel* and the data were cleaned (e.g. survey responses with < 10% of the questions answered were removed and the responses were then organized demographically). As only one of the research participants identified their gender as 'other', we could not specially consider this as a separate 'gender category' in our analysis and had to focus our gendered analysis on men and women. We asked research participants only indirectly whether they self-identified as early-career researchers (ECRs) in a question that asked: 'If you are an Early-Career Researcher (up to 5 years post-PhD, excluding career breaks), how has the pandemic impacted your mentoring or supervision?'. This could mean that we underrepresented the number of ECRs who completed the survey. We also classified anyone who stated that they received research supervision as an ECR, irrespective of whether they provided an answer to the indirect question referred to above.

All data cleaning, data visualization and statistical analysis were carried out in *RStudio* version 4.1.0 using the packages *epiR*, *dplyr* and *ggplot2* ([Wickham 2016](#), [RStudio Team 2020](#), [Stevenson & Sergeant 2021](#), [Wickham *et al.* 2021](#)). To assess the statistical significance ($P \leq 0.05$) of gender, age and career stage

Table I. Demographics of research participants.

| Affiliation (<i>n</i> = 435) | Employment (<i>n</i> = 383) | | Field (<i>n</i> = 396) | | Highest degree (<i>n</i> = 318) | | Age (years; <i>n</i> = 317) | |
|-------------------------------|------------------------------|--------------------------------|-------------------------|--------------------------------|----------------------------------|---|-----------------------------|----------------|
| University | 47% | Permanent position, full-time | 51% | Life sciences | 37% | Bachelor's degree | 5% | 20–29 10% |
| Research institute | 36% | Permanent position, part-time | 2% | Geosciences | 30% | Graduate certificate/ diploma | 3% | 30–39 33% |
| Self-employed | 2% | Fixed-term position, full-time | 17% | Physical sciences | 10% | Postgraduate certificate/ diploma | 3% | 40–49 26% |
| Non-governmental organization | 4% | Fixed-term position, part-time | 6% | Social sciences and humanities | 8% | Master's degree | 19% | 50–59 16% |
| Private business | 2% | Self-employed | 3% | Governance | 1% | PhD | 65% | 60–69 11% |
| Retired | 2% | Unemployed | 4% | Management | 4% | Other | 3% | 70 or older 3% |
| Other | 8% | Postgraduate research student | 16% | Logistics and operations | 3% | <i>Gender:</i> 49.7% of the participants identified themselves as women, 48.6% as men, 1.2% opted for 'prefer not to say' and 0.3% (i.e. 1 person) identified as 'other' when asked about gender identity | | |
| Multiple affiliations | 13% | Other | 1% | Other | 6% | | | |

Note: Demographic survey questions were optional, thus the number of responses (*n*) in each category differs.

on participants' answers, χ^2 tests and odds ratios were used for categorical and binomial questions, respectively. The tests were run using the function *chisq.test()* and *oddsratio()* and the results were collected in the cleaned *Excel* sheet.

Limitations of our study

The cultural and linguistic bias of participants is a significant limitation in the extent to which the results can be interpreted as a representative sample of the international Antarctic research community. The limited uptake of the surveys that were available in Spanish, Russian and Mandarin Chinese and the dominance of four Anglophone countries imply that our results will have a linguistic and cultural bias that ought to be overcome in future work. The low response rate to the surveys that we made available in other languages might be due to different cultural attitudes to surveys or to the effectiveness of our selected dissemination methods, which included email lists, SCAR's networks and fora, social media and the personal connections of our very international team of researchers. Of course, general survey fatigue, highly constrained work time or simply other concerns and priorities at a turbulent time may also have contributed to a lower response rate than hoped for. The low level of international diversity in participants, and especially the low response rate for non-English surveys, is in itself informative and may indicate that language was not necessarily the main impediment but that there might be a cultural bias regarding surveys. For instance, one of our collaborators confirms that in Russia, for example, people are suspicious of surveys given the history of the country and the political regime. This also emphasizes the need for improved transnational coordination and consultation efforts regarding Antarctic research to

ensure that a wider range of voices, notably different ethnicities and main languages, are heard. It is worth noting that the invasion of Ukraine by Russia in February 2022 resulted in tensions between Russia and other countries, stopping much science diplomacy with Russia. This crisis is likely to have lingering effects on research coordination in transnational bodies, such as SCAR, whose decision-making forum includes both Ukrainian and Russian delegates. Additionally, researchers in China could be understandably cautious about online surveys given the extent to which China's government monitors Internet activity.

Furthermore, our survey included a range of Likert-scale categorical questions, which are limited in that participants select from a set of answer options, and so the results may be biased by the categories provided. We attempted to minimize this potential bias by always including a 'don't know' option and by giving participants the option to skip questions. Despite this, categorical responses make results more comparable, reducing the need for interpretation during data analysis.

Results: the impact of COVID-19 on Antarctic researchers' professional and personal lives

Our findings highlight that the pandemic and associated measures and restrictions significantly impacted Antarctic researchers' careers and performance indicators. Fieldworkers were adversely affected by cancelled, postponed or altered field seasons due to severely restricted logistics in most NAPs. However, the pandemic also affected researchers whose work does not rely on fieldwork. With lockdowns occurring around the world and work-from-home mandates, Antarctic researchers' work lives shifted online, causing unprecedented strains on cognitive functioning and mental health.

While these changes and challenges affected most Antarctic researchers, our findings indicate that some groups were impacted more than others. For instance, ECRs, researchers with caring responsibilities and women broadly reported more significant adverse impacts. The forthcoming sections examine the impacts of the pandemic on ECRs, by gender and by disciplinary focus.

Impacts of the pandemic on early-career researchers

A total of 85% of ECRs said that their work had been adversely affected by the COVID-19 pandemic. Distractions of working from home - including those arising from the presence of children, spouses or flatmates - were often reported as moderately impactful. Although the pandemic affected established researchers and ECRs (see Fig. 2), our findings show that the pandemic's impacts were perceived as more extreme by ECRs. In total, 29% of the ECRs reported stress as extremely impactful. Overall, stress was the most negative effect of the pandemic in terms of result significance ($P < 0.05$; Fig. 2). We speculate that stress rather than other negative impacts (e.g. caring for loved ones or having/had COVID-19) dominated in our responses because of a relatively large proportion of participants from Australia and New Zealand, where COVID-19 cases had been very low at the time of the survey due to strict national border closures.

In the open-ended questions, ECR participants elaborated on their concerns about their professional future and career progression. To illustrate, a female ECR geoscientist from the UK noted the 'lack of Postdoc opportunities in my field after PhD completion (or increased competition for existing opportunities)'. This perspective was echoed by other ECRs, including a female Australian physical scientist who was concerned about

not being able to finish my PhD because I had to drastically change my thesis and now have difficulty concentrating and staying motivated [and] not getting a post-doc because there are now even fewer jobs than before and perhaps less funding.

Perhaps, unsurprisingly, our survey results suggest that ECRs believed that more fellowship opportunities and bursaries to cover lost income ($P < 0.001$) are helpful strategies to improve their career prospects and attenuate the negative impact of the COVID-19 crisis.

Postgraduate students disproportionately suffered from lost fieldwork opportunities given the relatively constrained degree completion timelines. One female British geoscience ECR observed 'the loss of field work opportunities that I would have gained this year but were cancelled with [sic] negatively affect my future career path'.

ECRs also had immediate and long-term financial concerns

[t]hat my dissertation is going to take a lot longer to write than I expected so my funding will run out and I will have to get a job which will slow me down more. Also this means longer with a terrible income that means I can't save and my retirement is not getting any contributions. Also if I do finish getting a job in research seems very unlikely. (Australian, female, physical scientist, ECR)

Open-ended responses generally highlighted the deep uncertainty felt by ECRs across disciplines:

The world's in pretty rough shape, so my concerns are plentiful! I'll comment specifically around Antarctic research though: I'm a PhD student located in Australia working in the social sciences and humanities. Covid19 has triggered a financial crisis for Australian universities (not sure to what degree this is replicated elsewhere) and as a result the career prospects of HDR [higher-degree research] students and ECRs in general are projected to shrink considerably, particularly in the disciplines I work across, where opportunities were pretty slim to begin with. In terms of the future, I'm really concerned about job prospects, which can make it hard to stay motivated at times. (Australian, humanities and social sciences, ECR)

This extract brings to the fore the precarity of ECRs in academia, which we have already flagged in the introduction as a structural issue, and its impact on mental health. Academic precarity, in particular for ECRs, is a longer-standing issue that has been exacerbated by the pandemic, as the responses to our survey suggest. Issues relating to mental health (e.g. increased stress, anxiety, trouble concentrating and lack of motivation) were very impactful to ECRs ($P < 0.001$), as Fig. 3 illustrates.

Despite additional challenges for mental wellbeing, access to confidential counselling services was not found to be a significant intervention for ECRs ($P > 0.05$), potentially indicating that although ECRs wanted support, institutions were not providing it or ECRs did not know how to access it. Instead, ECRs relied on supervisors or mentors for personal support and research advice. However, 42% of ECR participants noted that supervision or mentoring had decreased as a result of the pandemic (see Fig. 4).

When asked about potential positive impacts (see Fig. 5) resulting from changes to the work environment or personal lives that COVID-19 measures may have introduced, the benefits of working from home were valued by researchers across all career stages, as were the opportunities presented by being able to access

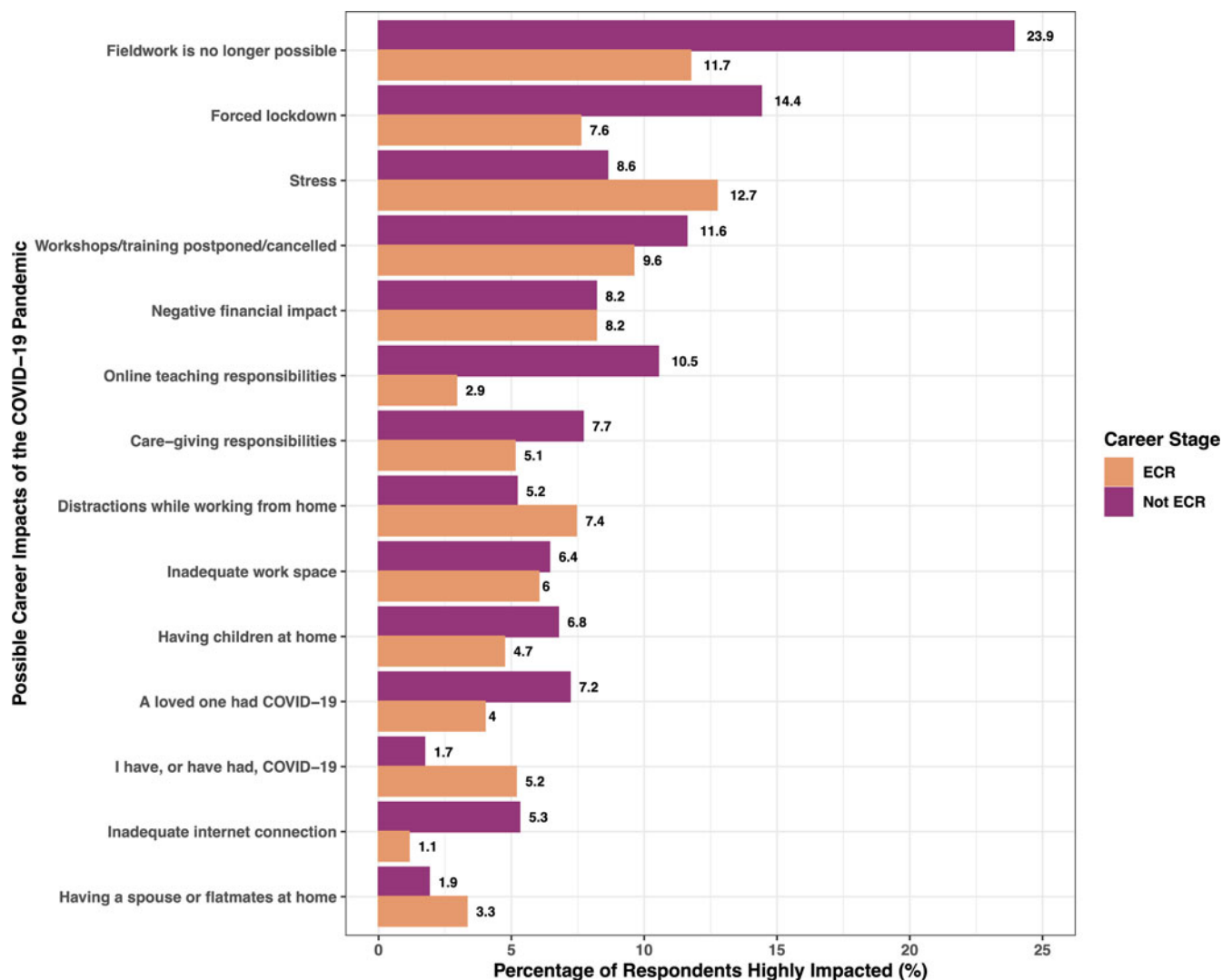


Fig. 2. Negative impacts of the COVID-19 pandemic by career stage showing the proportion of those who answered 7 (highly impactful) compared to all other answers. ECR = early-career researcher.

online workshops, training or conferences. No significant differences were noted between different career stages as far as any potential positive impacts are concerned ($P > 0.05$).

The gendered impacts of the pandemic

In this study, women appeared to report more negative impacts from the pandemic. For example, 92% of women compared with 79% of men stated that their work had suffered due to COVID-19. Table II provides an overview of the negative impacts the COVID-19 pandemic had on research productivity according to gender. As is shown in Table II, women reported more extreme negative financial consequences from the pandemic, including inadequate home office space and being less productive due to stress. We note that a

self-selection bias might be partially responsible for the differences summarized in Table II, with those women researchers who suffered more hardship during the pandemic possibly being more motivated to complete our survey in order to share their experiences.

Fears around contracting COVID-19 or health guidelines being ignored were not significantly different by gender ($P > 0.05$). Feelings of uncertainty about the future commonly arose in women's closed-question responses, alongside high levels of perceived stress.

The findings highlight that women researchers, and in particular those with caregiving responsibilities, faced additional challenges related to increased caring burden and unpaid/domestic workload:

[What worries me most is] personally that I have fallen behind due to childcare responsibilities; there has been

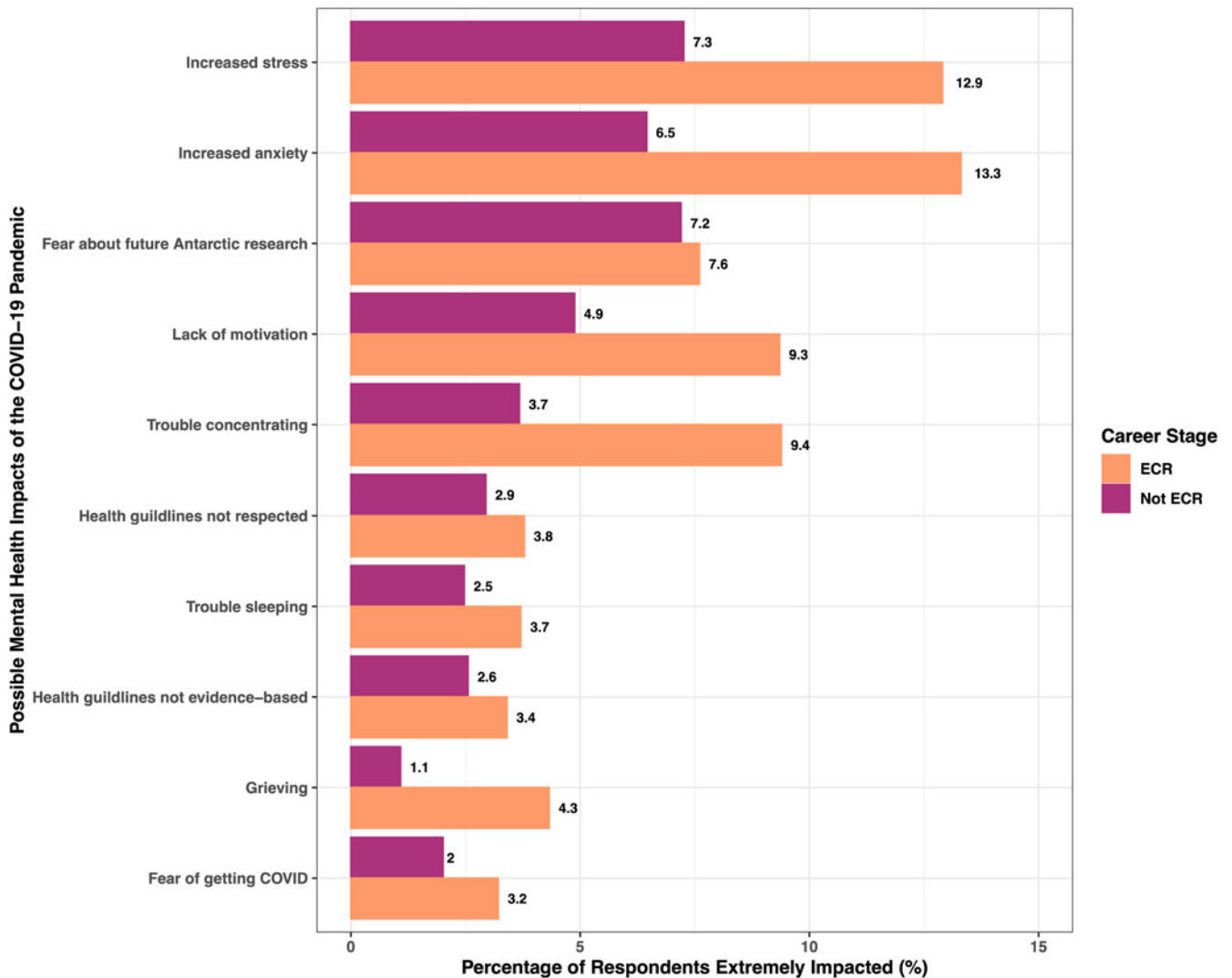


Fig. 3. Impacts of the COVID-19 pandemic on mental wellbeing by career stage showing the proportion of those who indicated an 'extreme impact' compared to all other answers. ECR = early-career researcher.

a narrative that some people have 'more time' due to being stuck at home, but for me the opposite is true, and I have zero time for any kind of long term planning or skill development/diversification. (Female, geosciences postdoctoral researcher)

Most research participants (68%) lived in a household with others, and 40% of those households included children under the age of 18 years. Caring responsibilities were broadly defined and extended to elderly parents, partners, other family members and sometimes a combination of these. As illustrated in Table II, more women reported caregiving responsibilities as a negative impact, but the impact of children is relatively evenly split. Men also reported disruptions to work in relation to the presence of children at home, which could be explained by the fact

that women in many industrialized nations are more likely to juggle paid and unpaid caring work, whereas men might not have needed to consider the practical realities of this previously.

Men and women reported an increased administrative workload. However, women reported a higher teaching load and more pronounced decreases in their academic productivity compared to their male counterparts (see Fig. 6).

As outlined in Table III, the COVID-19 pandemic has had a significantly different impact on the mental wellbeing of women. In this study, women were significantly more negatively affected by high levels of stress, anxiety and trouble concentrating ($P < 0.001$; see also, for comparison, the overall impacts of the pandemic on mental wellbeing, which are presented in Fig. 7). While we could postulate that women might be

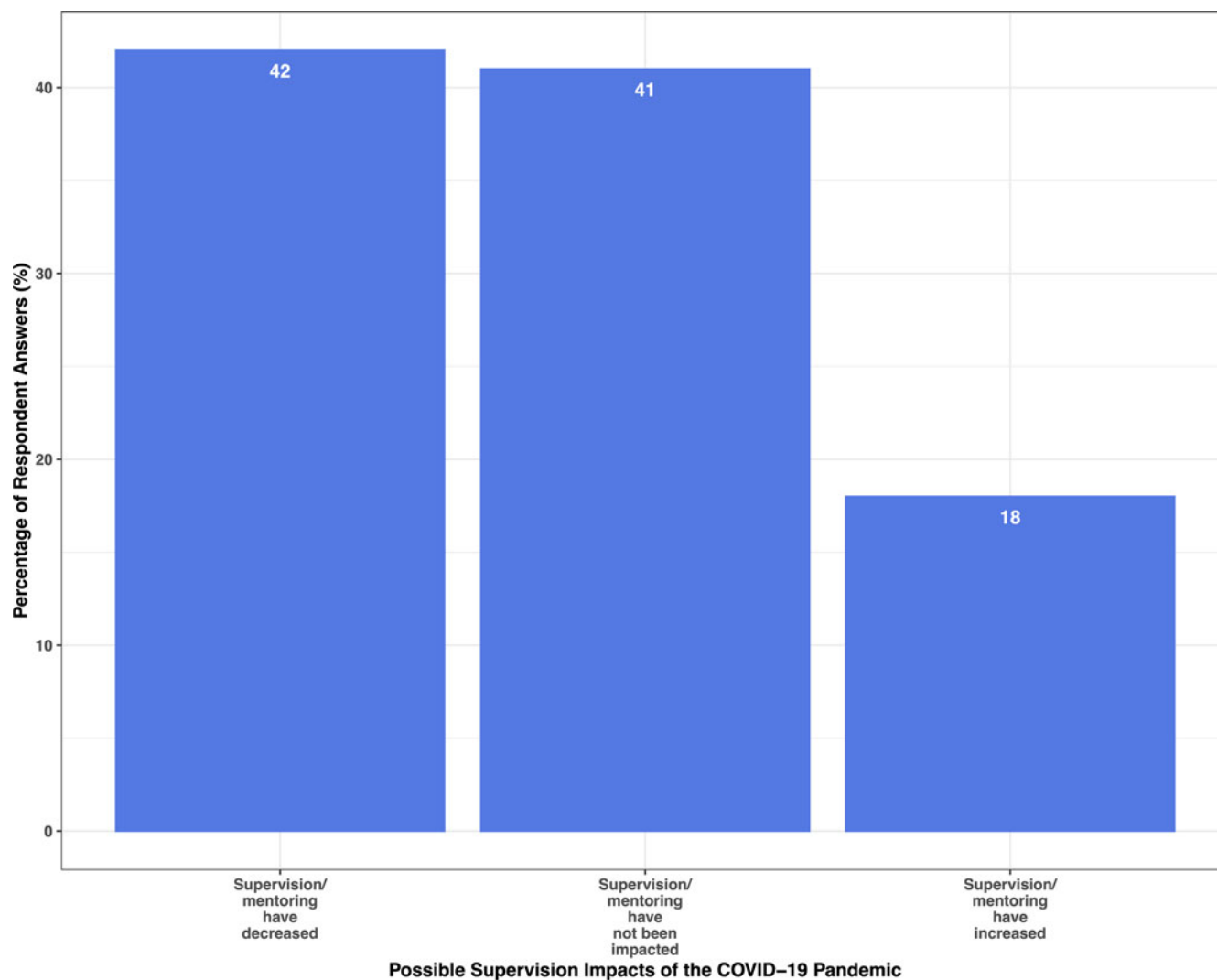


Fig. 4. Effects of the COVID-19 pandemic on supervision and mentoring for early-career researchers.

more willing to share more intimate accounts of their mental states, the gender differences here are too significant to be attributed merely to the potentially greater openness of women to report on mental wellbeing. Rather, we need to ask why stress levels and anxiety were greater in women and why the pandemic had such adverse impacts on women's concentration and self-motivation.

Counselling services and the ability to share experiences in a confidential and friendly setting were highly insignificant when it came to gender ($P = 1$), potentially showing that when men accept that they need help, they prefer to discuss their personal and professional concerns with a health professional away from the workplace rather than seeking in-work support. This may highlight the importance of confidentiality to men and may explain one reason men were less likely to report that they were negatively impacted. This perhaps

confirms the role of gender stereotypes such as masculinity in terms of aiming not to appear to be struggling or vulnerable.

The additional uncertainties introduced by the pandemic further aggravated the stress felt by female ECRs:

[What worries me most is] that there won't ever be a 'return to normal'; I can cope with a lot of the COVID-19-related negatives, but I am terrified about permanently losing access to what brought me joy in life. (Female, geosciences postdoctoral researcher)

Despite pronounced gender differences in the impact of the pandemic, responses from women and men generally aligned in relation to the work-related opportunities created by the pandemic. As Fig. 8 illustrates, most research participants reported benefits related to working

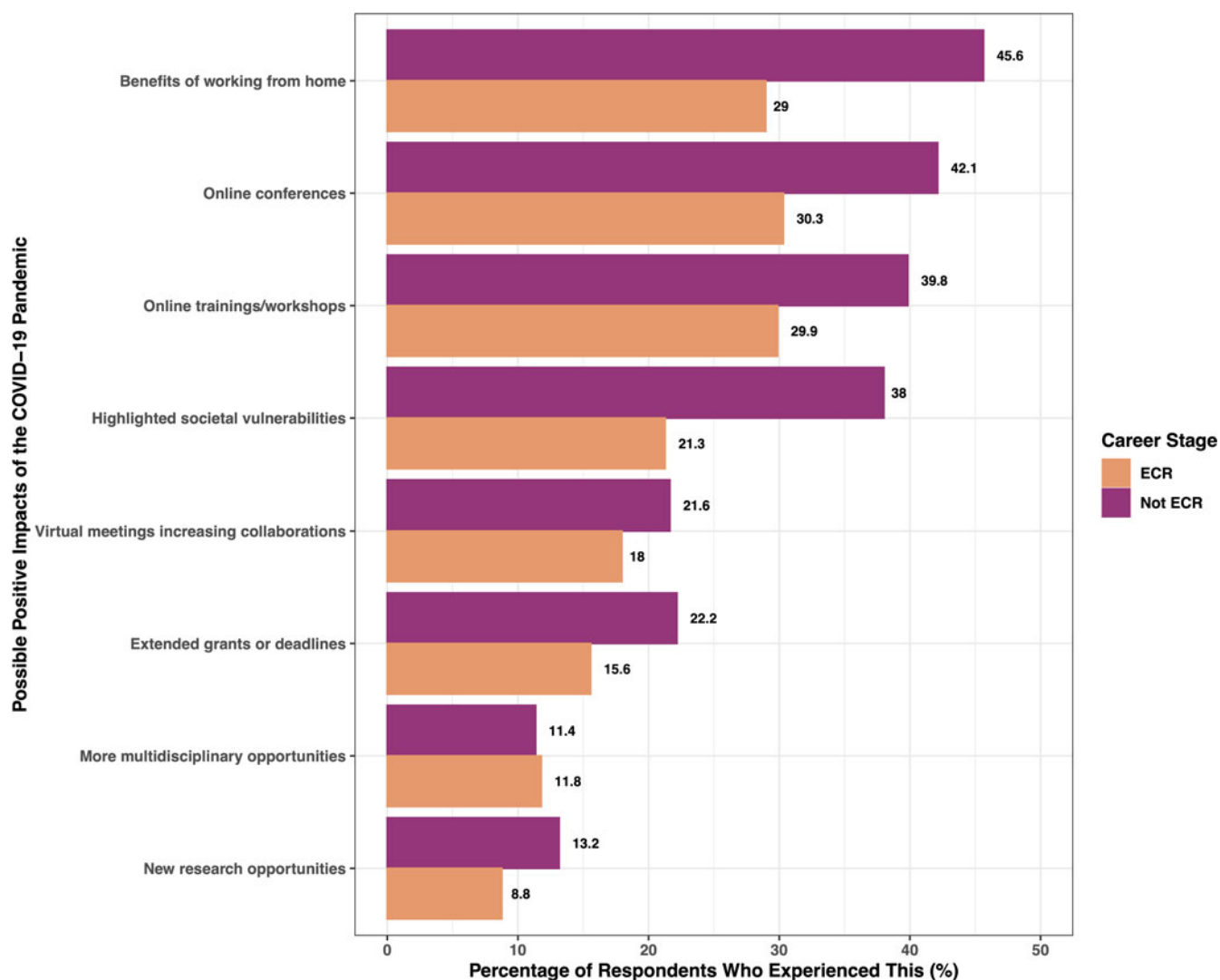


Fig. 5. Opportunities resulting from the COVID-19 pandemic by career stage showing the proportion of those who reported having experienced this compared to all other answers. ECR = early-career researcher.

from home - from not having to commute to greater flexibility with respect to juggling unpaid and paid work.

In addition, many participants commented on benefitting from the opportunity to attend online training, workshops or conferences that would otherwise not have been accessible. Online conferences can be beneficial especially for those scientists who may experience greater difficulties due to increased caring responsibilities or disabilities (e.g. scientists with young children and scientists with disabilities). Both men (42%) and women (58%) reported that they benefitted from virtual meetings that resulted in an increase in collaboration.

A statistically significant finding from our survey ($P < 0.05$) is that research participants considered the fact that COVID-19 highlighted social vulnerabilities as a positive outcome, as the first step to addressing such

vulnerabilities was to be aware of them in the first place. This may show that women felt that some of the issues they face in research and academia and how personal issues and shocks are handled and experienced by them were being appreciated by the wider research community.

Differences by discipline

For 57% of the participants, fieldwork in Antarctica was 'extremely important', followed by a further 27% for whom it was 'very important' and 10% for whom it was 'important'. Only 2% of the participants indicated that they were desk-based researchers who did not undertake fieldwork. As a result, it is unsurprising that most participants observed a negative impact of the pandemic on fieldwork across all career stages (see Fig. 9).

Table II. Negative impacts of COVID-19 on productivity by gender.

| | Women | Men |
|--|-------|-----|
| Stress | 66% | 38% |
| Fieldwork is no longer possible | 54% | 54% |
| Negative financial impact | 50% | 34% |
| Necessary workshops or training sessions have been postponed or cancelled | 47% | 50% |
| Inadequate workspace (e.g. setup of desk, lack of technical or laboratory equipment) | 42% | 27% |
| Forced lockdown | 33% | 26% |
| Caregiving responsibilities | 27% | 20% |
| Inadequate Internet connection | 24% | 20% |
| Online teaching responsibilities | 23% | 19% |
| Having a spouse or flatmates at home | 22% | 12% |
| Having children at home | 20% | 22% |
| A loved one had COVID-19 | 8% | 6% |
| I have, or have had, COVID-19 | 3% | 6% |

Note: Any moderate to extreme negative impacts felt were considered for the purposes of this assessment.

Almost half of the research participants reported that the 2020/2021 field season and their fieldwork in the Antarctic or the Southern Ocean had been cancelled, and close to a third of participants indicated that their fieldwork had been postponed (see Fig. 10). Very few participants noted that their fieldwork would proceed as scheduled. A female life scientist highlighted that the pandemic's impacts on just one field season would have a ripple effect well into the future as 'disruptions to Antarctic field seasons will snowball and make it even more difficult for new investigators to get funding for Antarctic fieldwork'. This concern was common among other researchers as well as science support staff. Reduced NAP logistics coupled with national border closures and restricted scientific exchange via fellowship programmes or other academic institutional exchange programmes compounded the impact of fieldwork cancellation/postponement:

If I can't enter Australia, I can't do my fellowship on Antarctic krill. I was counting on that fellowship as a step towards a career in Antarctic science. Even if I can enter Australia, how much of my field work will be cancelled? Half already has been - if much more the project will fall apart. (British-American, female, life scientist, mid-career)

Finally, beyond its impact on individual researchers, the cancellation or amendment of planned Antarctic fieldwork also threatened important long-term monitoring programmes and longitudinal studies that rely on regular access to the field in order to deploy equipment, download data or undertake field observations, whose value, at least in part, lies in building a consistent, long-term dataset and following a

Table III. Negative impact of COVID-19 on mental wellbeing by gender.

| | Men | Women |
|--|-----|-------|
| Increased stress levels | 55% | 79% |
| Trouble concentrating | 46% | 74% |
| Increased anxiety | 44% | 72% |
| Fear about the future of Antarctic research/work | 64% | 70% |
| Lack of motivation | 45% | 69% |
| Fear others do not respect the new health guidelines | 43% | 59% |
| Fear about getting COVID-19 | 38% | 50% |
| Trouble sleeping | 33% | 49% |
| Fear that health guidelines are not evidence based | 36% | 39% |
| Grieving | 22% | 37% |

Note: Any moderate to extreme negative impacts felt were considered for the purposes of this assessment.

methodical approach to data collection that is often planned years in advance.

Discussion

The findings highlight that the COVID-19 pandemic significantly impacted the Antarctic research community and that it accentuated existing inequities in academia, especially around academic precarity and gender differences in workload and career progression. In this respect, our research aligns with other studies examining the barriers to women and ECRs in academia (Rabanal *et al.* 2021).

The study findings highlight that uncertainty about the future and the fate of their research careers are causes of elevated stress and anxiety among ECRs. This resonates with other scholarship (Woolston 2021) showing that ECRs were underpaid, worked long hours beyond their schedules and became less satisfied with their current employment situation during the pandemic. These uncertainties were compounded by distractions resulting from working from home, including children, a spouse or flatmates being around, or not having adequate workspaces, all of which were reported as moderately impactful by many of the research participants (see also NOCA 2020). Other impediments to productivity might relate to lack of adequate resources, such as suitable technology and Internet connection, which have been highlighted as key elements to enable the work and wellbeing of ECRs (Rabanal *et al.* 2021).

To cope during the pandemic, ECR participants highlighted the importance of having access to mentors for both personal support as well as research advice and support (see also Woolston 2020). As our results (see Fig. 4) show, the pandemic has caused a reduction in supervisors' availability and capacity, leading to decreased access to supervision and mentoring for 42% of ECRs (see also NOCA 2020).

Particular groups of employees in academic institutions are advantaged: those that are straight, white, middle

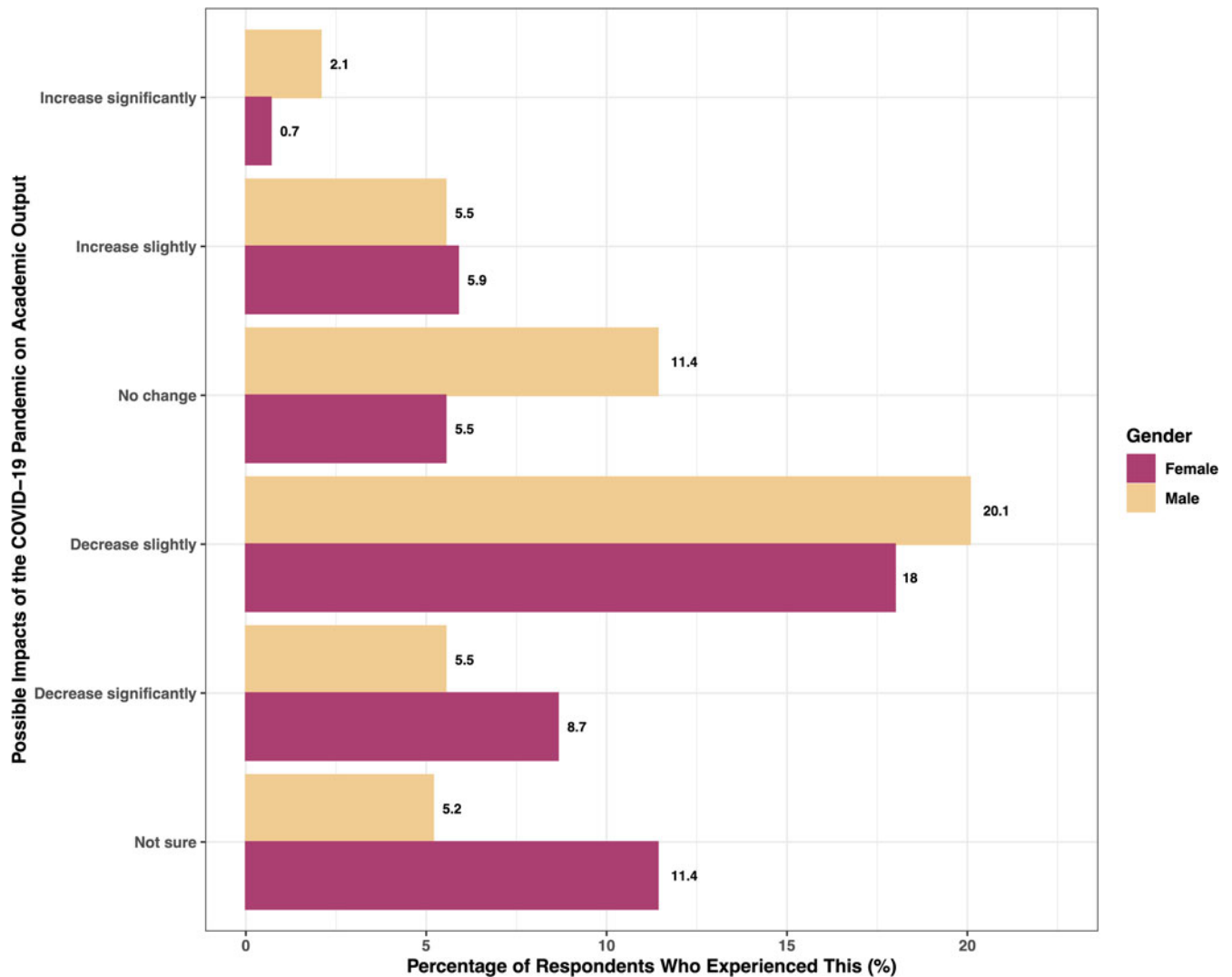


Fig. 6. Implications of the COVID-19 pandemic for academic output by gender.

class, able bodied and male (for exceptions, see Acker 2006). All people, regardless of social identity, are positioned as having equal opportunity to succeed in academic institutions (Blackmore 2006). However, gendered (and other) social inequalities are invisible and legitimated (Acker 2006), rendering inequality more difficult to articulate and address (Kelan 2009, Sullivan & Delaney 2016), and it is this kind of inequality that has been further deepened by the COVID-19 pandemic.

The results from our survey highlight that women researchers, and in particular those with caregiving responsibilities, often face additional challenges related to an increased caring burden and workload (Greely 2020, Hennekam & Shymko 2020, Moen *et al.* 2020, Power 2020, Camerlink *et al.* 2021, Scharf 2021). Most of the research participants (68%) live in a household with others, and 40% of the latter households include children under the age of 18 years. In addition to

looking after children, caring responsibilities also extended to parents, partners, other relatives and sometimes a combination of these. Caregiving responsibilities are often assumed by women (Shockley *et al.* 2021), who have reported an increase in household and caregiving responsibilities as a result of the COVID-19 pandemic (Nash & Churchill 2020, Bonacini *et al.* 2021, Langin 2021) and have thus been subjected to significant 'multifactorial stress' (Connor *et al.* 2020).

Indeed, women in our study revealed that they were 'extremely impacted' by childcare responsibilities during the pandemic compared to men, an observation that is also reflected in other studies that reported an increase in the already disproportionately large amount of caring for children and other family members falling to women after the onset of the COVID-19 pandemic (Hennekam & Shymko 2020, Power 2020). The resulting stressors are potentially tied to women's understanding that the

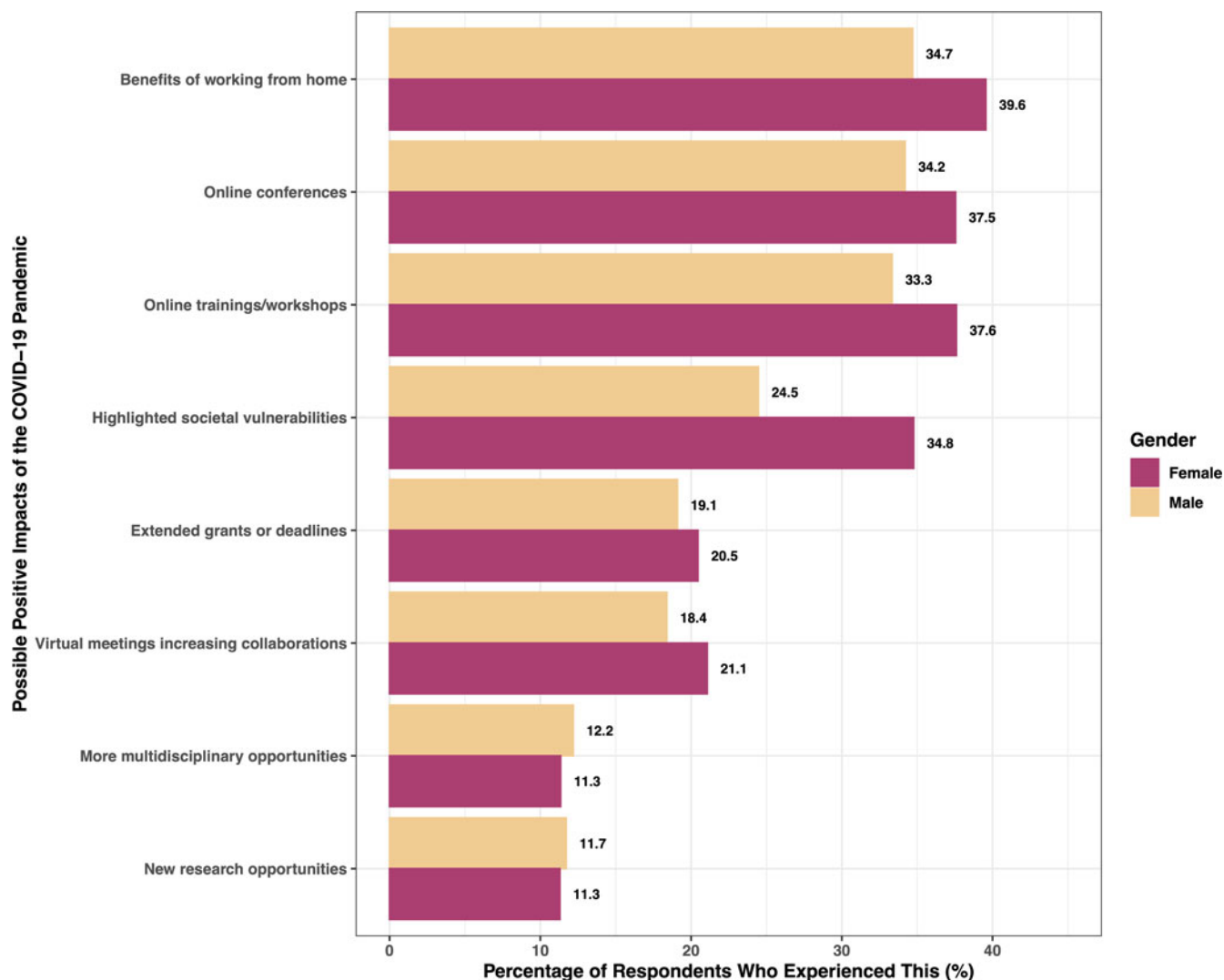


Fig. 7. Opportunities resulting from the COVID-19 pandemic by gender showing the proportion of those who reported having experienced this compared to all other answers.

social value of caring is generally not recognized organizationally. For example, a female geoscientist from the USA wrote in one of her responses to our survey:

Biggest fear: That my career will not recover from pandemic related impacts, and I will be pushed out of academia. I've lost opportunities at work (e.g. can't take on additional projects because I provide 90% of childcare), will have a large gap in publications, can't write proposals that are necessary to fund my position, etc.

Similar sentiments were voiced by participants in an exploratory French study that employed a survey, diary entries and interviews to make sense of the strategies individuals used to cope with the lockdown in France (Hennekam & Shymko 2020). Hennekam & Shymko (2020: 797) found that women were more likely to

neglect their own needs in order to be there for their children and other family members in need, which led to an 'intensification of gender performativity ... [and] in the reinforcement of "masculine" and "feminine" gender roles during confinement'.

The aforementioned added pressures had a significant impact on women academics' mental health. In fact, the mental health section of our survey yielded the most dramatic differences in terms of perceived impacts between men and women. Such gender differences in relation to the impact of the pandemic on mental health were also found by other researchers. For instance, a cross-sectional survey on mental health related to COVID-19 (Turna *et al.* 2021) found that women and younger people suffered more anxiety, depression and stress during the pandemic, especially if they had experienced mental health issues in the past (Etheridge

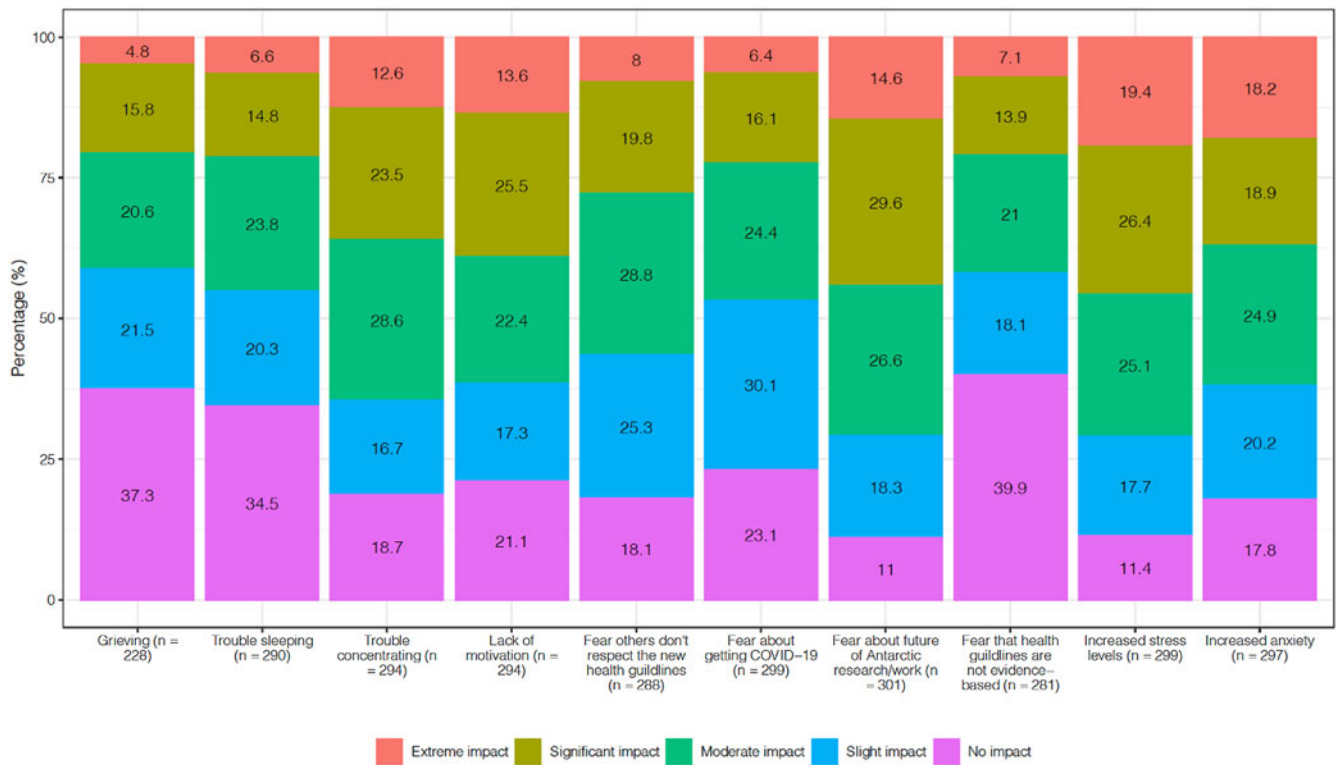


Fig. 8. Negative impacts of COVID-19 on mental wellbeing ($n = 301$).

& Spantig 2022). Gender differences might be a result of loneliness being experienced more severely by women rather than men due to physical distancing rules and forced lockdowns.²

More than merely additional childcaring duties and household duties, which women self-reported to invest more time into than men (Etheridge & Spantig 2022), this sense of loneliness had a considerable negative impact on pandemic-related stress and depression in women, who in pre-pandemic times enjoyed a larger network of social relationships with others. Those who reported having fewer friends in pre-pandemic times were less affected by mental health issues after COVID-19 physical distancing rules were enforced (Etheridge & Spantig 2022). A similar gender gap in the impact of the pandemic on mental health has been reported for the USA (Adams-Prassl *et al.* 2020), and, just like the aforementioned British study, Adams-Prassl *et al.* (2020) concluded that this gender gap was not so much due to economic differences between men and women than the social and psychological dimensions related to social networks.

²The adverse impacts of enforced isolation on mental stress, and in particular on levels of anxiety, depression and post-traumatic stress, were highlighted in other research (Sica *et al.* 2021).

Similarly, women in our study were also more likely to identify the extreme impact of having inadequate working space compared to men. As feminist philosopher Fiona Jenkins (2020) argues, universities, for example, requisitioned '... the home as a condition of continuing to work, and they have taken away the office as part of what was previously offered to enable people to work'. Such a move implicitly privileges the entrepreneurial (male) academic worker, as 'home' is imagined in particular (gender-neutral) ways by neoliberal employers and governments as a costless resource and a 'frictionless site of interpersonal relations' (Jenkins 2020) where caring for children and other family members is invisible.

Academia is also heterogeneous in terms of the structural features of employment. Academics face differing levels of precarity depending on their national context, social identity/background, career stage, field of study and institutional affiliation. For instance, Kınıkoğlu & Can (2021) argue that COVID-19 has exacerbated and diversified academic experiences of precarity. For example, in our study, men responded that they were generally impacted less severely by lockdowns and having children at home. It is possible that these men were in research positions and had favourable living conditions or had partners to support their careers and could use lockdowns to maximize their productivity. It is

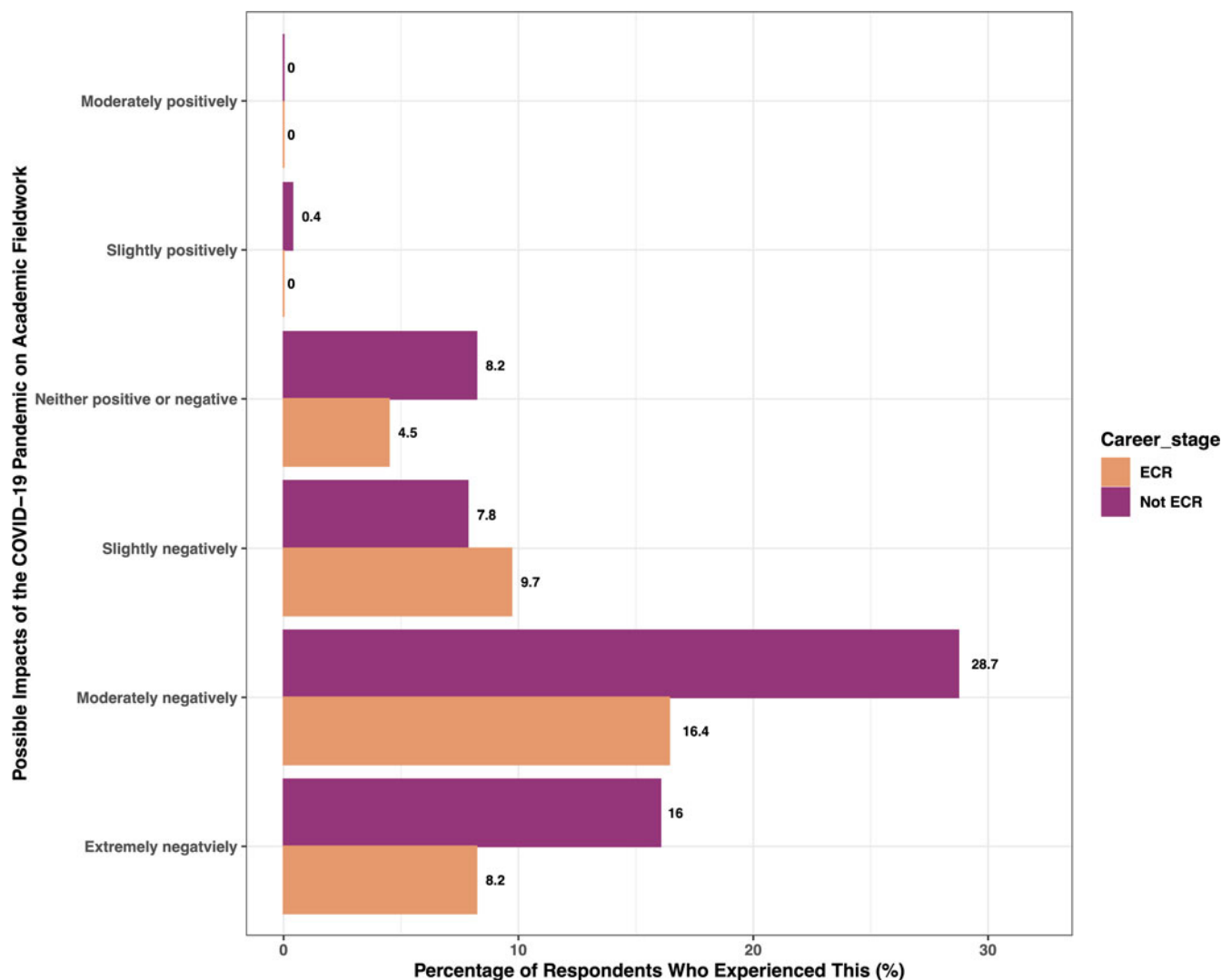


Fig. 9. Impacts of the COVID-19 pandemic on Antarctic fieldwork by career stage. ECR = early-career researcher.

also possible that men are more likely to respond that they were not very much impacted and to 'act tough'. By comparison, women in more precarious working arrangements or who lacked institutional support may have reported more negative impacts.

Experiences of the pandemic are also shaped by geography, and the impacts of COVID-19 have been uneven. There are strong differences in national/international scales and across aspects of social identity (e.g. gender, race/ethnicity, social class, sexuality, etc.), and the pandemic has thrown into stark relief the intersectional nature of inequality (Eaves & Al-Hindi 2020, Maestripieri 2021). The research participants would have been experiencing very different conditions in their national contexts at the time they responded to the survey. Their experiences of working from home would be a direct consequence of health regulation in their country of residence. COVID-19 mortality rates,

for example, have varied significantly depending on whether national governments have been able to contain the virus by mobilizing public health resources (e.g. rapid testing, personal protective equipment, access to ventilators, vaccinations, etc.; see Chung *et al.* 2020). Many countries have found that their healthcare systems have been unable to cope with the onslaught of COVID-19 hospitalizations due to lack of resources (financial, physical, human, etc.). Similarly, people in cities around the world have experienced multiple lockdowns and periods of isolation or quarantine.

The scholarship suggests that public health responsiveness during COVID-19 is also a function of culture. For instance, wearing masks is a widely accepted practice in daily life in part due to past experiences with pandemics (e.g. severe acute respiratory syndrome or SARS) in many parts of East Asia, whereas mask-wearing became highly politicized in parts of

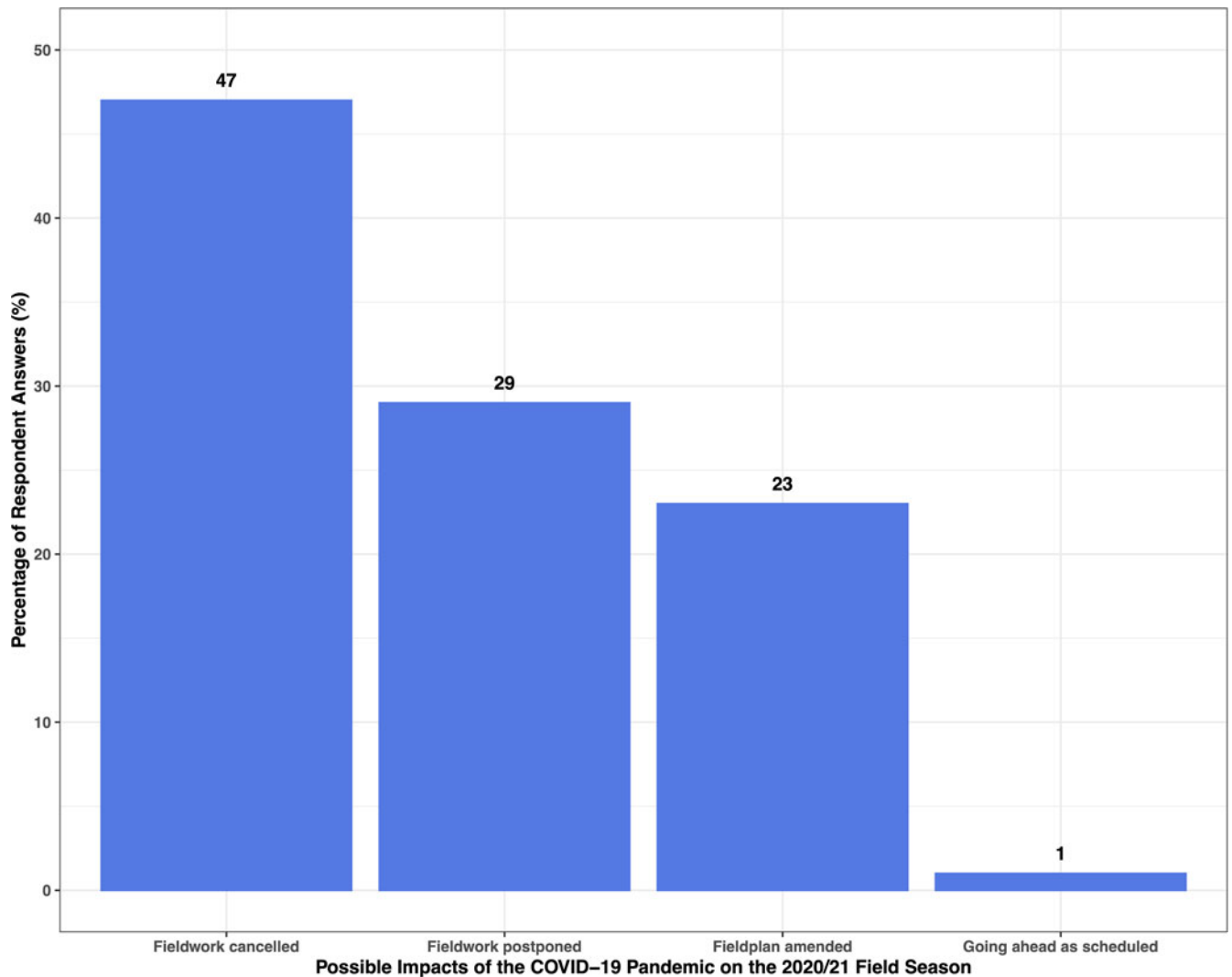


Fig. 10. The effect of the COVID-19 pandemic on the 2020/2021 Antarctic field season.

North America, the UK, Sweden, New Zealand and Australia. The global public health message that everyone should stay at home and limit contact assumed that everyone has an adequate home to stay in and can practice physical distancing or quarantine easily. In many parts of the world this has not been possible, and home, therefore, has mediated the reproduction of many of these health inequalities and the gendered geographies of people's working environments. Whereas home and work may have been undertaken in different spaces previously, working from home has collapsed the boundaries between them, creating new tensions depending on the context (see Chan *et al.* 2020). Whilst working in paid employment is often discussed as the primary means by which Western, middle-class, educated women have escaped the burden of domestic labour, the pandemic has entrenched it, as working

women have taken on even more caring responsibilities as day-care centres, schools and care facilities closed during the pandemic. Various lockdowns have exacerbated gendered disparities in unpaid care work and the impact of gendered violence.

In terms of Antarctic fieldwork, where gender did not appear to be a strong moderating factor, geographical and cultural contexts are potentially strong exclusionary mechanisms. For example, in countries with good vaccine access, travel and in-person meetings resumed earlier. Elsewhere, many researchers were still facing multiple precarities due to the health crisis, border closures and lack of access to vaccinations. There are significant ethical considerations embedded in how international collaborations proceed given that remote collaboration is going to be a staple of scientific work moving forward (Scerri *et al.* 2020).

Recommendations and conclusions

Considering that the most prominent negative effects of the pandemic were its impacts on mental wellbeing, our study highlights an unmet demand for access to personal and professional support in times of crisis. Hence, employers, including universities and research institutions, should consider how they can best prepare for future crises and ensure not only that support networks are in place, but also that employees are aware of them. Outside of work, access to mentors for personal and research advice, especially for ECRs, could be facilitated through platforms that connect those needing support with those who can offer it. As confidentiality was seen as important, especially for men who responded to our survey, this feature should be built into any platform providing such support services.

In addition to negative impacts on mental wellbeing, the pandemic forced many to work from homes that lacked the resources needed to perform the required tasks. The results of our study suggest that sometimes simple adjustments, such as the provision of reliable Internet access, might alleviate the intensity of such negative impacts. Employers and mentors should explore ways that can help employees to ensure that the latter have adequate working space at home. Additionally, there is a pressing need to offer financial support, especially for ECRs, to cover the basic resources needed for home offices.

In general, one of the most helpful strategies that institutions can adopt to decrease the severity of the impact of the pandemic is to provide financial support through, for example, extended deadlines for funded projects or proposals and fellowships to cover lost income, as well as to facilitate networking and the creation of new research collaborations, even if those may not involve travel to other institutions.

In effect, these recommendations are implementing the Job Demands-Resources Model (Demerouti *et al.* 2001) with an approach that should balance job demands that cause strain (in this case, a pandemic) with job resources that empower individuals to help them deal with those demands (in this case, reliable Internet access, financial support and psychological support). Implementing this model might be particularly relevant for those involved in Antarctic scientific research that requires fieldwork - meaning scientists as well as support staff. Not knowing when their work could continue as well as the scattered COVID-19 infections in Antarctic ships and bases would require different forms of coping and support from those in these situations than people who worked from home - or who could have worked from home with adequate support.

Considering that approximately half of the participants valued certain consequences of the pandemic, such as working from home and being able to spend more time

with family, as well as the opportunities to attend events and to undertake training online, we suggest that we may want to rethink the status quo of our compulsion to connect via physical spaces. Institutions and employers should explore the possibilities of offering more flexibility as to where employees perform their work, and future conference and training organizers should consider offering hybrid versions of events to allow and to enable the participation of people who are not able or not willing to travel.

Lastly, for the researchers whose work relies on access to the field, the inequalities between the impacts of the pandemic on different countries point to the need for a more robust remote international collaboration among researchers. Further research with people in underrepresented countries and researching in languages other than English would inform contextually needed actions, as well as comparing Antarctic locations with other locations deemed to be distant from their home country (e.g. for France; Dupéré 2020).

To conclude, the larger structural issues that the pandemic accentuated, including clear patterns of inequities and the disproportionate impact of the pandemic on women, reflect a well-known gender gap. While this issue requires more analysis on how to alleviate the intensity of the negative impacts on women, we argue that institutions should be encouraged to proactively take steps towards addressing gender inequities, especially around teaching and service workloads, to soften the impacts of this present - and future - pandemics, which will have lasting consequences not only for the Antarctic research community, but also for humankind as a whole.

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Author contributions

DL was responsible for the initial concept, approach and design of the research described in this manuscript, and AH managed the research team and the development of the manuscript. All authors contributed to the developing and refining the survey questions and contributed to the analysis of the results. GECC and PM-Q led the quantitative data analysis component, and DL led the qualitative data analysis, with all authors first individually coding data then iteratively comparing and revising codes as required. DL and AH compiled the coded data and undertook a final review of the

results of the qualitative analysis. DL and AH led the preparation of the manuscript, and all authors contributed written text and reviewed the relevant scholarly literature. All authors contributed to the editing of the manuscript prior to submission.

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