

RESEARCH ARTICLE

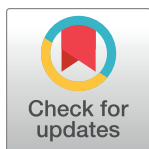
# Coming in from the cold: Addressing the challenges experienced by women conducting remote polar fieldwork

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## Abstract

Remote fieldwork is an important component of polar research across both physical and social sciences. There is increasing recognition that the inherent logistical, physical, psychological, and interpersonal challenges of remote polar fieldwork are not felt equally across the polar research community, with minority groups often disproportionately affected. Although historically lacking diversity, the demographics of polar researchers have shifted, and the way polar research is conducted has been changing in response. However, there are still barriers to equal participation. Removing these barriers would attract scientists from more diverse backgrounds and improve scientific outcomes. We explored the lived experiences of those who identify as women in polar fieldwork through a review of current literature and an anonymous survey, using existing networks to connect with women working in polar research. We synthesised survey responses with regards to topics such as harassment, hygiene, inefficient communication, gendered work expectations and responsibilities to form a holistic understanding of the key fieldwork challenges faced by women. The majority of survey respondents (79%, n = 320) had encountered negative experiences during fieldwork, with the most common and impactful issues relating to field team dynamics and communication, sexism, rest, and weather. Many other issues including fieldwork preparation, work expectations, harassment, and personal space and privacy were also raised by respondents. We identify critical points of action from the survey results and in literature and propose strategies to remove barriers to participation and improve the experiences of women in polar fieldwork. These include individual- and organisational-level strategies for pre, during, and post fieldwork. A diverse polar research community is imperative in order to address the challenges presented by current unprecedented climate change. Though this study focussed on women's experiences, we seek to advance the discourse on challenges faced by all minorities in polar research.

research originates from a survey focused on respondents' experiences in polar fieldwork. The sensitive nature of this dataset, coupled with the small and closely-knit polar fieldwork community, raises concerns about the potential identifiability of individuals based on combinations of answers, including protected characteristics. The APECS International Directorate will serve as the primary contact for any future data requests. Requests should be directed to the APECS International Directorate at [info@apecs.is](mailto:info@apecs.is).

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## 1. Introduction

The polar regions—the Arctic, Antarctica, and the Qinghai-Tibet Plateau (often termed the Third Pole)—are currently experiencing some of the most pronounced and rapid environmental changes globally [1]. As a result, understanding the underlying processes and possible impacts of climate change in these regions is of utmost importance. A diverse and inclusive polar research community is imperative when aiming to solve complex global problems related to climate change [2–4].

Globally, women and other marginalised or minority groups encounter persistent challenges in receiving equal treatment and opportunities. In line with fostering sustainable development worldwide, the promotion of women's empowerment and gender equality is a key focus of the internationally recognized Sustainable Development Goal (SDG) 5 for 2030 [5]. Women constitute only about 30% of the global scientific community [6], while in climate science, women constitute only 22% of authors of the 100 most highly cited climate science papers 2016–2020 [4], and only 122 of the 'Reuters Hot List of the world's 1000 top climate scientists' were women [7]. In addition, 41% of the responding women authors for the Intergovernmental Panel on Climate Change (IPCC) landmark reports identified gender as a barrier to their success [8, 9].

Barriers also persist for equitable participation of women in polar research [10]. Whilst the overall number of women in this field is not known, underrepresentation is evident in polar organisations; women make up 39% of the British Antarctic Survey [11], 40% of the Australian Antarctic Division [10] and 21% of investigators in ArcticNet Canada [2]. However, whilst the polar research community has historically lacked cultural and gender diversity, there has been a slow but steady growth in female participation, accompanied by a reduction in institutional barriers [12–14]. Currently 57% of the members of the Association of Polar Early Career Scientists (APECS) are women (personal communication with APECS International Directorate, November 2023), and the proportion of female-led Antarctic research has shown an upward trend since the 1980s [10].

The ubiquitous challenges of climate change and the urgency to act does not allow for the exclusion of skills or knowledge and underrepresentation of women in climate sciences [15]. In addition, the political and socioeconomic struggles associated with climate change are expected to disproportionately impact women and girls [16]. A more diverse scientific community is necessary to find comprehensive and inclusive solutions to global challenges. Diverse research groups have benefits such as producing research that is perceived to be of higher quality, as well as increased leadership quality [17]. Whereas lack of diversity is an impediment to a strong and sustainable climate research community and has substantial societal implications and economic consequences [18]. In addition, a greater number of female leaders may foster greater commitment to sustainable development and contributions to the achievement of global efforts such as the SDG 13 Climate Action goal [19].

Institutional changes are required to improve diversity in polar research [20]. Frameworks, policies, and entities dedicated to fostering equity, diversity, and inclusion (collectively known as 'EDI') have played a role in increasing the involvement of women and other minority groups in polar sciences. However, these initiatives have been critiqued for addressing minority categories in an undifferentiated manner, rather than a holistic and intersectional approach [21, 22]. Moreover, there are concerns about the risk of inadvertently fostering an environment where distribution of support is imbalanced across minority groups [23], and that these measures may not be strong enough to bring about substantial and meaningful change [2].

EDI initiatives rarely extend to fieldwork settings, even though fieldwork is an integral part of polar research for many disciplines and comes with its own set of risks and issues. There is

increasing recognition that the inherent challenges of fieldwork are not felt equally across the polar research community, with minority groups often being disproportionately negatively affected [10, 24, 25]. Fieldwork continues to present obstacles for women, potentially perpetuating the "leaky pipeline" phenomenon of an escalating underrepresentation of qualified women in higher career stages [2, 10, 18, 25–27], although this framework has been critiqued for not incorporating intersectional disadvantage [10, 26]. These barriers to equal participation in fieldwork may affect career progression, as fieldwork opportunities, participation, and leadership roles are prerequisites for many careers, particularly in field-based sciences such as geosciences [28]. Enhancing the quality of fieldwork operations and the overall experiences of underrepresented groups, particularly women, can advance diversity and sustainability in polar climate change research. Reflecting the relatively recent emergence of this discourse (acknowledging the longstanding nature of the issue itself), there is a scarcity of documented knowledge and reports on female experiences in polar fieldwork, as well as pathways/strategies towards fostering a more inclusive research practice.

### 1.1 Literature review

In a scoping literature review on available peer-reviewed and grey literature (*i.e.*, news articles, blogs) on women conducting polar fieldwork, a total of only  $n = 31$  records could be identified to address women or female experiences in polar fieldwork (see [S1 Text](#)). Of these records,  $n = 29$  (93.55%) are assumed to have a female first author. Until recently, issues faced by female researchers in isolating and confined environments of remote fieldwork [24] and polar fieldwork [29] remained disregarded in scientific publications. Contributions to this emerging discourse stem from anecdotal or biographical publications (e.g. [30]) as well as formalised studies and surveys [10] that aim to establish a baseline for women-specific experiences in the field.

The isolating nature of polar fieldwork [29] has the potential to leave minority and marginalised groups particularly vulnerable. For example, Nash et al. [10] identified physical barriers, unpaid work, gender bias, lack of opportunities, and sexual harassment as issues faced by women in Antarctic research. Sexual harassment has been at the forefront of a growing discourse surrounding women and fieldwork, propelled by the momentum of the global #MeToo movement [25, 31]. In recent years, reports have emerged from several major national polar programmes documenting instances of extreme abuse of female scientists and fieldworkers [32]. In addition, in a landmark survey, Clancy et al. [33] found that 71% of female field scientists had experienced harassment while doing fieldwork, one in four had been assaulted, and 84% of those harassed women were 'trainee-level' (student and post-doctoral). Early career researchers (ECRs) are therefore often carrying the load of both experiencing a disproportionate level of harassment whilst having a key role to play in establishing an open dialogue on inclusivity and equity in polar research practices [25, 34].

There has been a significant increase in publications on women involved in polar fieldwork over the past two years with three records in 2022 (9.4% of the total records found) and eight records in 2023 (25% of the total records found). The limited existing body of literature focuses predominantly on Antarctic fieldwork and its unique characteristics of remoteness and historically routed heteronormativity and masculinity [10, 21, 31]. Publications by Nash and colleagues on the matter have been pivotal to the awareness of specific challenges, such as issues of hygiene and sexual harassment [10, 31, 35, 36]. Arctic field research (e.g. [2, 12, 30]) and global ship-based fieldwork [37] have equally gained attention and diversify the perspectives on these issues. The overall low number of publications does, however, not allow for an in-depth systematic review and statistical analysis.

## 1.2 Study aims

This study builds upon published work and focuses on collating the lived experiences of women conducting polar fieldwork through a survey published herein. The authors aim to add to the discourse surrounding the unique challenges faced by this minority. A holistic understanding of the challenges women face is needed in order to identify strategies to improve their participation and experiences. We propose strategies that address the specific needs articulated by survey respondents, which could aid in creating a more diverse and inclusive polar community overall.

## 2. Methods

### 2.1 Survey design & implementation

The target group of the survey encompassed people who identify as women and have conducted or are conducting fieldwork in the polar regions. Polar research was defined as research of all academic disciplines occurring in the Arctic, Antarctic, and the Third Pole, while fieldwork was defined as practical work conducted by a researcher in the natural environment, rather than in a laboratory or office.

This survey drew inspiration from Beniest et al. [38] and Cech et al. [39] and took into account guidelines provided by the National Science Foundation [40], the National Center for Women & Information Technology [41], and the United Nations [42]. Invitations for participation in the survey were shared over various institutional and international mailing lists and forums, as well as Facebook groups and personal contacts during September and October 2023. We aimed to reach as many people as possible, thus, reflecting a diverse community of respondents. We acknowledge that the authors' backgrounds may have influenced the networks the survey reached and potentially reduced sample representativeness. The survey was only made available in English, which may have further reduced the pool of potential respondents.

The survey explored three main aspects: demographics of respondents, fieldwork characteristics, and fieldwork experiences. These aspects included the following topics: demographics, fieldwork type, fieldwork preparation, fieldwork practicalities (communication, physical aspects, rest breaks), working in a team, post-fieldwork debrief, negative experiences, and options for feedback. The survey consisted of a combination of multiple-choice questions (including open-ended options, hereafter "free text options"), rating scale questions, dichotomous questions, and open-ended questions (the results of which are hereafter "long-form responses"). There were no compulsory questions. For the complete list of questions see [S2 Text](#).

### 2.2 Survey ethics statement

To ensure participant anonymity, the survey did not collect any individual identifiers such as names, IP addresses, or contact details. As survey responses would be anonymous and data would not be identifiable to individuals, institutional ethical approval was not sought. Before the start of the survey, potential participants were informed of the research aim, methods, and scope, as well as potential survey outputs, data anonymity and data protection policy, potential risks, and researcher background and contact details in writing (Information text, see [S2 Text](#)). After reading this information, participation in the survey implied consent, with all questions optional. Since the researchers had no direct contact with participants and data were anonymised before access and analysis, a formal informed consent process was not used. To further ensure the anonymity of the participants, small subgroups were merged and

identifying attributes, as well as an individual's full set of responses, were not analysed or shared collectively. Only a smaller subgroup of the research team had access to the data for analysis, which was saved in a secure storage, and not permanently stored locally. Furthermore, any statements or wording in the long-form responses that could have led to the recognition of an individual's institution, country of origin, or a certain expedition were removed from quotations used in this article.

### 2.3 Survey data analysis

Survey responses were downloaded in.csv format from Google forms on the 6th November 2023. Demographic data of all survey respondents was summarised using a circular packing algorithm [43] implemented in the R package 'packcircles' v 0.3.6 [44], where proportion of answers was denoted by circle size and the question was denoted by colour. After the demographic analysis we excluded respondents who did not respond "woman" when asked which gender they identified as in the survey, in order to conduct further analysis on the experiences of people who identify as women. The multiple-choice answers were transformed to numerical categories to simplify the data handling with python 3.7.10 [45] and R v 4.3.2 [46] to visualise results. The following python packages were used: pandas v 1.2.4 [47], numpy v 1.20.2 [48], and matplotlib 3.4.1 [49]. As all multiple-choice answers had a free text "other" option, resulting answers were manually categorised by the authors, sometimes leading to additional categories which were not part of the preset answers. Demographic questions, multiple choice questions, rating scale questions, and dichotomous questions were summarised numerically as the proportion of respondents per question. Analyses and plots conducted in R used the tidyverse packages [50].

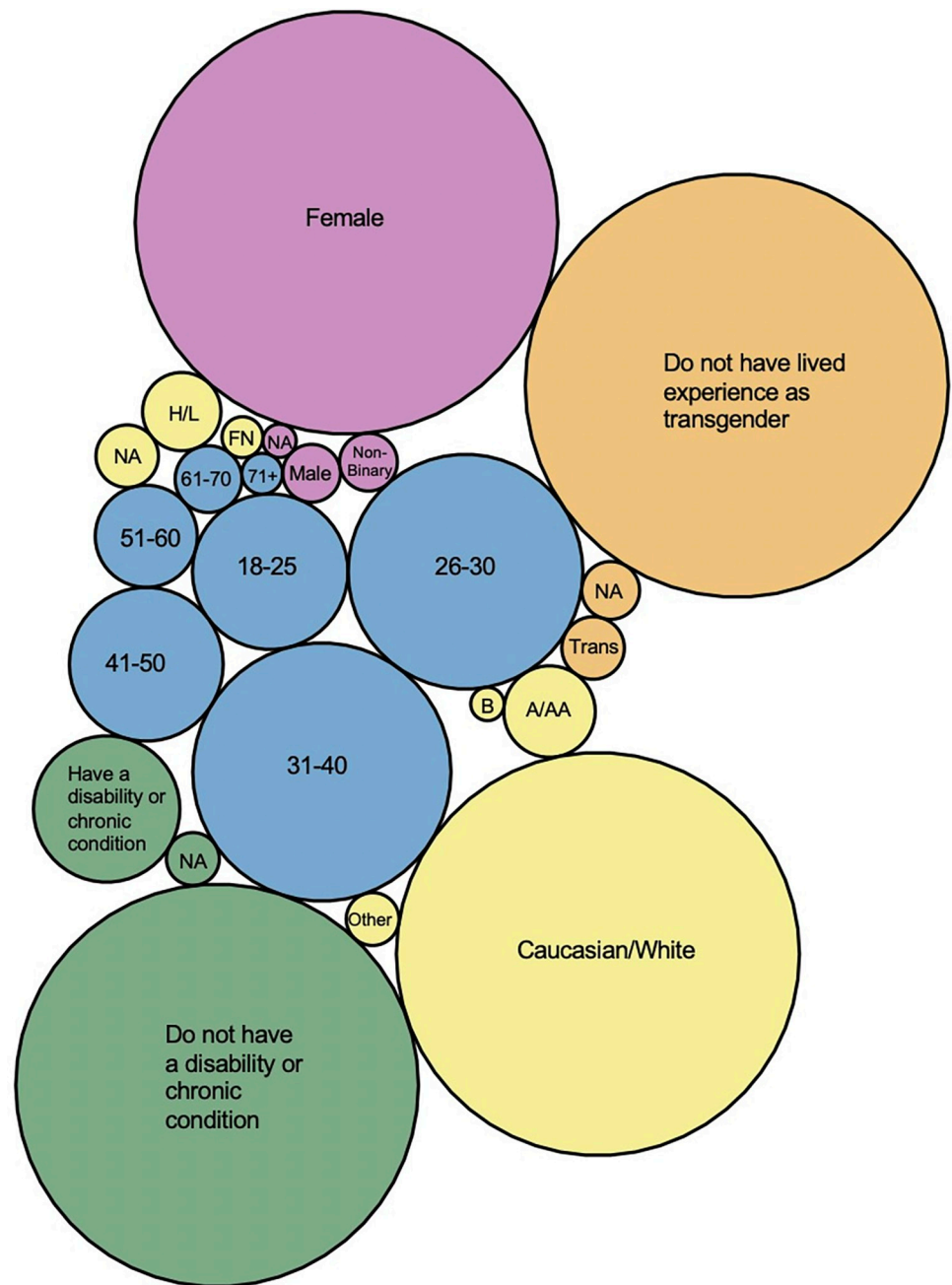
The most commonly used words in long-form responses to the questions "Please feel free to elaborate on these [negative] experiences, if you would like" and "How do you feel about conducting fieldwork in the future?" were visualised using word clouds, in which the proportion of times a word was used by survey respondents was denoted by the size of the word within the word cloud. The word clouds were constrained to include words that were used by a minimum of four respondents and non-indicative words, such as prepositions, were excluded from the word cloud. Analyses were performed using R Studio v. 2023.09.0 [46] and the R packages 'ggplot2' version 3.3.6 [51], 'wordcloud' version 2.6 [52] and 'stringr', version 1.5.0 [53]. The long-form responses were also manually reviewed for quotations related to topics that had emerged as important themes within the numerical survey results. Additional themes that emerged as important in the long-form responses (*i.e.*, topics or issues that were consistently raised by multiple respondents) were identified during this process and included in the results. In the results, quotations were reported as verbatim, with corrections for spelling and conciseness indicated by '[. . .]'.

## 3. Results

### 3.1 Demographics of survey respondents

The survey was completed by 338 respondents between 26th September - 6th November 2023. Of these, 96% identified as woman ( $n = 324$ ), 1.8% identified as man ( $n = 6$ ), 1.5% identified as non-binary ( $n = 5$ ), and the rest ( $n = 3$ ) as others or no answer was given. The majority of respondents were between 26–40 years old (66%,  $n = 221$ ) and described their race or ethnicity as Caucasian/White (86%,  $n = 299$ ). Most respondents did not identify as someone who lives with a disability or chronic condition (87%,  $n = 295$ ), or as having lived experience as a transgender person (95%,  $n = 324$ ). Demographic information is summarised in Fig 1. Respondents' polar fieldwork was associated with 31 different countries, primarily within Europe





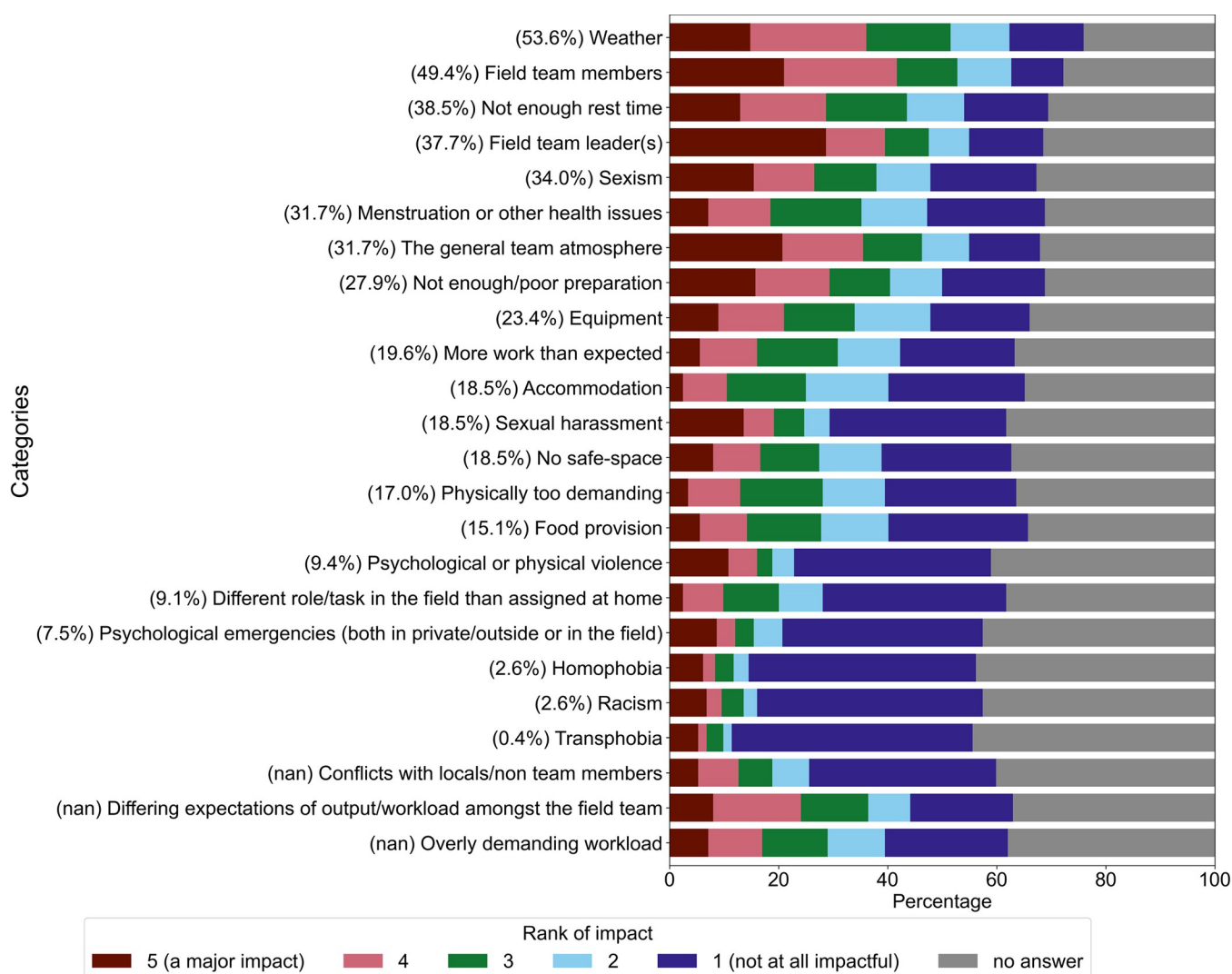
**Fig 1. Summary of the demographics of survey respondents, where larger circles represent a greater proportion of respondents, coloured according to the demographic characteristic.** Age of respondents is reported in blue, identified gender is reported in pink, identified ethnicity is reported in yellow, lived experience as someone with a disability or chronic condition is reported in green, and lived experience as a transgender person is reported in orange. 'A/AA' represents Asian/Asian American, 'B' represents Black, African, African American, or Afro-Caribbean, 'H/L' represents Hispanic/Latinx, 'FN' represents First Nations, and 'NA' represents the proportion of respondents who chose not to answer.

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(56%,  $n = 190$ ), followed by the USA (21%,  $n = 70$ ) and Canada (13%,  $n = 45$ ). When undertaking fieldwork, 54% of respondents said their native language was the main language of communication ( $n = 180$ ). For more detail on demographic results, see [S3 Text](#).

### 3.2 Pre-fieldwork preparation

The quantity and quality of preparation experienced by the participants, both in regard to fieldwork skills training and space for questions, was shown to be variable. The majority of respondents ranked their feeling of fieldwork preparedness as 4 or 5 (1 = not prepared at all, 5 = very prepared) ( $n = 322$ ). Only 0.6% ( $n = 2$ ) stated that they did not feel (at all) prepared. At the same time, ‘not enough/poor preparation’ was one of the most common and impactful reasons for negative field experiences (Fig 2). The respondents described preparation as “*Chaotic [ . . . ] safety and personal needs were not discussed*” and responded that “*We were mostly prepared for the science element of fieldwork by the science leads. Not much was said about the living element*”. Multiple respondents highlighted the lack of preparation for topics such as menstruation, toileting, and hygiene: “*Never had any discussion on periods*” and “*We didn’t discuss toilet and hygiene arrangements*”. On the other hand, some respondents were supported



**Fig 2. The reasons for negative field experiences among respondents ( $n = 324$ ) and their corresponding impact on fieldwork.** Twenty-three reasons could be selected in the multiple response question. The result of this question is indicated by the number in parenthesis sorting the reasons from the most common one at the top to the least common one at the bottom. The last three reasons were not included in the multiple-choice question. The stacked bars next to each reason describe the impact of it, asked in the follow-up question on a 1–5 scale (1—not at all impactful and 5—a major impact).

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through a more carefully organised preparation process: “We were prepared through peer discussions [ . . . ] and by the fieldwork manager, preparations took place over several months” and “We were given detailed written down information and [ . . . ] the possibility to ask anonymous question[s]”. See [S4 Text](#) for additional responses.

### 3.3 Post-fieldwork debriefs and communication

As with pre-fieldwork preparation, the experience of respondents varied widely with regard to the use of post-fieldwork debriefs as a tool to reflect upon the work undertaken and learn from field experiences. Post-fieldwork debriefs were experienced by 48% of respondents ( $n = 320$ ), while debriefs which included discussions on team dynamics were experienced by only 27% of respondents ( $n = 302$ ), and the option for written feedback after fieldwork was experienced by 23% of respondents ( $n = 320$ ). This is reflected in how respondents experienced field and post-fieldwork communication; only 55.6% of respondents chose 4 or 5 for post-fieldwork communication (1 = very poor, 5 = excellent). Participants who experienced debriefs mentioned a variety of aspects: “I felt it was managed very well, placed no blame, but considered whether we might collectively be able to improve a similar situation in the future. [ . . . ] so we had a really open meeting to address the types of support we needed from people in leadership roles, even when the tasks at hand weren’t necessarily ‘leader’ tasks”. See [S5 Text](#) for additional responses.

Despite variable post-fieldwork communication and the substantial proportion of respondents conducting fieldwork in a non-native language, communication during fieldwork was generally reported to be good, with 71.8% of respondents choosing 4 or 5 in the 1–5 ranking for communication in the field ( $n = 323$ ). Respondents reported that “We, as a field team, generally let everyone provide ideas and communicate what they need done to get their research complete to make sure everyone succeeds” and “Personalities and communication skills play a big part in communication success. [ . . . ] There are always going to be some people who struggle to speak up, or who aren’t as good at articulating themselves, so there is some skill required from those leading to ensure people are consulted [ . . . ]” and “My voice was always important. I didn’t have concerns to tell if I had a worse day at the beginning of my period”.

### 3.4 Negative fieldwork experiences

The majority of respondents (79%) reported that they had a negative polar fieldwork experience ( $n = 320$ ). The proportion of respondents with negative experiences and the reasons given for negative experiences were similar, regardless of age group membership ([S1](#), [S2 Figs](#)). The five most common reasons for negative experiences were related to weather, field team members, amount of rest time, field team leaders, sexism, and menstruation or other health issues ([Fig 2](#)). The reasons that were attributed to being most impactful were field team members, field team leaders, weather, team atmosphere, and fieldwork preparation ([Fig 2](#)). With weather consistently shown to be a defining factor for a negative fieldwork experience, the free-text responses provide insight into its impact: “Weather in the [A]rctic [is] always an unknown and sometimes hinders sampling or forces to change plans—this is unavoidable and is planned for when organising the trips” and “We had big problems with weather conditions (flooding, wildfires) but both times I was lucky enough to have a team that made the best out of it”. The impact of bad weather was linked to team communication by some survey respondents: “Severe cold injuries [were] the [ . . . ] consequence of the breakdown of team communication” and “The group always made sure people were keeping [ . . . ] warm”. A lack of appropriate field clothing for women’s bodies introduced additional weather-related challenges: “Peeing in a bodysuit is colder for someone that [has] to sit”.



In the word count analysis of long-form responses, where survey respondents were asked to elaborate on their negative fieldwork experience, 22% of respondents mentioned sexual harassment, 18% mentioned psychological difficulties, 9% mentioned violence, 4% mentioned racism, and 4% mentioned homophobia. Additional reasons for negative fieldwork experiences that were not explicitly mentioned in survey questions but were raised by respondents in free-text options and long-form responses included:

- Problems in the local community or with the local military and navy
- Cultural differences (for example in the research station or the local community, and particularly relating to alcohol consumption)
- Money (for example, hidden costs for kit and in the field)
- Physical safety in the polar environment
- Family-related communication issues and emergencies
- Travel and logistics
- Lack of institutional and PI support at home and in the field
- Psychological and mental health issues

### 3.5 Team dynamics and communication

Internal team dynamics and communication were an important influence on how participants perceived their fieldwork. The majority of respondents had good experiences with field teams, with 79.1% agreeing (ranking 4 or 5) with the statement “I felt generally comfortable among the members of my field team” (n = 321), 86.7% agreeing with the statement “I felt like I could participate in casual conversations among my field team” (n = 321), and 83.5% agreeing with the statement “I was usually included in the invitation for socialising before, during, and after fieldwork.” (n = 318).

However, issues relating to field teams were among the most common and most impactful factors causing negative field experiences. The long-form responses show that power structures and hierarchical factors played a role in these issues: “PI got incredibly stressed at sea in a leadership role, and reported any sign of disagreement [. . .], that person was targeted for the rest of the cruise as a problem member of staff. Constant volley of abuse, derision etc.” and “The hierarchical structure was deliberate and explicitly stated. When [trying] to address safety and logistical concerns, we were told we were causing trouble by one of the people in charge”. Another respondent felt that there was “No seeming ability to leave or address issues in the field, due to extreme remoteness and power dynamic” with another found that “People who behaved very irresponsibly were let off the hook largely due to personal connections. . . I think that people without personal connections to program managers or people in power were discriminated against”. For some participants, issues that had taken place in the field continued afterwards: “After returning back home, the PI started excluding and ignoring members of the team whose performance in the field he wasn’t happy with. This included those that tried to communicate concerns and shortcomings while still in the field”. Other respondents highlighted the variability of teams between different trips: “Some trips had good internal communication with good team dynamics and overall positive team morale and healthy boundaries. Whilst others were the complete opposite”. Issues relating to team members other than leaders were also apparent in responses (see [S6 Text](#)).

A lack of personal space and privacy were also raised as issues, with only 36% of respondents stating it was possible to create personal space from the rest of the team during

fieldwork. This could impact mental health during fieldwork, with one respondent commenting that *“Negative feelings arise when I don’t have access to my own space (shared tents for many, many weeks)”*. A lack of privacy was also linked to difficulty finding a confidant or safe space, for example: *“On board the research vessels or especially at the research stations, there is little privacy and I did feel that it was not possible to confide in many people without fear of the issue being disclosed to others”*. Personal space and privacy extended to hygiene issues where respondents struggled with *“Not enough privacy when menstruating in the field”*. Other respondents were working in teams where *“The group leaders [. . .] brought hygiene bags to the field with things like toilet paper, plastic bags for carryi[n]g the waste home, tampons”*.

### 3.6 Work expectations

Work expectations were also raised as a contributing factor to negative fieldwork experiences, with respondents stating that *“There was a mismatch of what we discussed the workload and rest days would be like and what they ended up being like. It was made known that this is how it would be and if you can’t handle it then deep field work is not right for you”* and *“Decisions were sometimes made spontaneously in the field that introduced significant physical challenges. The culture has tended to demonstrate a willingness to push through physical challenges, sometimes at the detriment to health and wellbeing”*. This attitude to polar fieldwork was summarised by another respondent as: *“Largely speaking, the biggest problem is that we are usually rushing to get everything done. Personal wellbeing and sustainability take second priority”*.

Many respondents directly linked differences in work expectations and task distribution with gender: *“[. . .] women are often the ones that have the most laboratory tasks, while male colleagues are often the ones that get to go out on the boat all day and bring the women home the samples for processing late into the night, [. . .] the females are often the ones making sure that everyone is well fed [. . .] and also are noticeabl[y] more involved in tidying up, etc”*. Another respondent reported that there was a *“Different perception of what women can handle, e.g. operating large machines”* and *“I [. . .] was proposed by my colle[a]gue to clean [the] laboratory inste[a]d of setting up equipment as it is a task more suited to a woman”* and *“I generally feel that sexism was always pervasive and affected my work”*.

Additionally, several survey respondents expressed a feeling of needing to work harder to prove themselves because they are female: *“[. . .] felt gender based. Male colleagues need less experience to be taken more seriously”*. This was reflected to some degree in the numerical survey results: although 83.4% of respondents agreed with the statement *“My fieldwork contributions were valued”* (n = 320), and 77% of respondents agreed with the statement *“My field team regarded me as a similarly qualified member”* (n = 320), 30.7% of respondents agreed with the statement *“In order to be recognised as a valuable member of the field team, I had to work harder than my coworkers.”* (n = 320).

### 3.7 Sexual harassment

Sexual harassment was raised by numerous respondents as an issue that negatively impacted their fieldwork experiences. One respondent said: *“[. . .] there were numerous cases of sexual harassment [. . .], sexist comments and actions, etc. that made the working environment at times unwelcoming and impacted my work”*. Sexual harassment occurred in various fieldwork locations and structures, from field stations to research vessels, and appeared to come from team members/scientists, crew, or locals (see [S7 Text](#) for more details).

Within the free-text responses, serious concerns were raised regarding the lack of adequate structures to report fieldwork harassment, and the lack of accountability when such reports were made. For example, *“I talked to my supervisor and asked for them to act differently. They*

### 3.8 Perceptions of future fieldwork

[illegible]

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*choice of field PIs” and “Always good. I am a career Antarctic field worker, I can’t imagine doing anything else”.*

Other respondents were aware of the potential for change and responsibilities they hold as team leaders in enabling a safe and enriching environment for all participants: *“My experience with an abusive leader was incredibly damaging to me in terms of confidence and overall happiness. In response, I have worked hard to support my own teams, and to stand up and speak when I observe bullying behaviour”* and *“I feel positive, as I am now in a more senior position and able [to] try and create better conditions for all involved in my field campaigns”*. One respondent highlighted the career risks associated with fieldwork: *“I have enjoyed doing fieldwork in the past, but I think it can hold back career development. It involves significant preparation time, with a high risk of weather or equipment failure leading to a lack of data collection. That is extremely risky while working on short, fixed-term contracts, when the next contract may rely on timely publications. I now choose to spend my effort on more reliably remote sensing and modelling projects with guaranteed outcomes”*. See [S8 Text](#) for additional responses.

## 4. Discussion

### 4.1 Insights from survey results

This project used a survey to investigate polar fieldwork specific challenges for women-identifying researchers to propose pathways to more equal participation. The representativeness of our survey sample in relation to the wider polar research community is uncertain, although the proportion of respondents who identified as white (87% of  $n = 324$ ) was similar to the proportion of people who identified as white (90% of  $n = 174$ ) in the Diversity in UK Polar Science Initiative Race Impact Survey [11]. The top countries associated with respondents’ polar fieldwork (USA, Norway, Canada, UK, Germany) broadly reflect the countries with the highest Arctic [54] and polar scientific research output, although Russia and China were underrepresented in our survey respondents [54, 55]. The survey was circulated through the authors’ networks and associated mailing lists, potentially limiting the representativeness of the survey respondents.

Fieldwork experience was not related to age or career stage, since the proportion of respondents with negative fieldwork experiences and their reasons were similar across age groups. Differing experiences between age groups were expected due to the recent increase in women’s participation in polar research [2, 10] and changing research culture [56]. The similarity of experiences across age groups may reflect the fact that respondents could answer in relation to single or multiple field experiences and may have referred to field experiences that occurred at different periods in the past.

Survey respondents overwhelmingly encountered negative experiences during fieldwork. The most common and impactful issues were related to field team dynamics and communication, sexism, rest time, and weather. The majority of respondents had some good experiences with field teams but issues relating to field team members and team dynamics were pervasive. Communication issues were also raised, with disparity between respondents’ mostly positive experience of in-field communication and the lack of post-field communication. Less than half of respondents had post-fieldwork debriefs, and most debriefs which did occur did not cover non-technical aspects such as team dynamics. Without debriefs there is no formal way to ensure that issues arising in the field are corrected for the next field trip, nor a defined space for team members to seek clarifications or support they may need [56].

Many other issues were consistently raised by respondents, including: no fieldwork preparation for issues that specifically concern women, different work expectations, gender stereotypical task assignment for team wellbeing and daily chores, harassment, psychological issues,

and lack of personal space and privacy. Another emerging theme was the role of power structures and hierarchies contributing to difficulties reporting harassment, and lack of accountability for problematic behaviour. Respondents (and authors) avoided naming specific expeditions or institutions, not only to protect anonymity, but to avoid putting careers at risk, with one respondent stating that “[...] a filtration of this information can jeopardize my opportunity to go in a next expedition, and to participate in national programs in my field”. Despite the negative experiences of most survey respondents, a culture of resilience and passion for research was evident. Most respondents enjoyed fieldwork overall, were planning to conduct remote fieldwork in the future, and expressed positivity regarding future plans.

The results of this survey highlight problems faced by women in the polar research community, independently of fieldwork characteristics to their work. On the other hand, it is not possible to infer that these issues are exclusive to women. In fact, some aspects identified here are likely relevant to all people involved in fieldwork and across minority groups. Other minorities and marginalised groups may experience structural barriers and issues which were beyond the scope of this study and were not explicitly included in the survey [11, 26]. Intersectional identities in particular would result in unique sets of overlapping barriers in polar research [21]. These aspects, nonetheless, warrant further attention, and go beyond the scope of our dataset. Further survey limitations are discussed in [S9 Text](#).

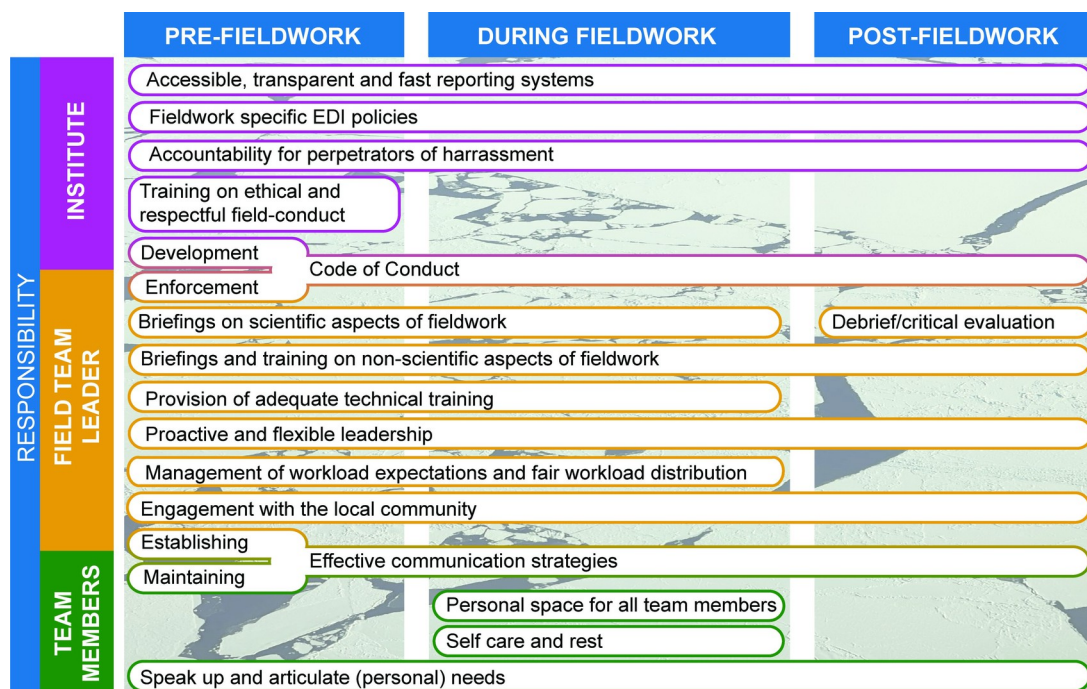
## 4.2 Strategies to improve polar field experiences for women

Several key areas for improving the experiences of women participating in polar fieldwork emerged from the issues raised in the survey and literature. At a fundamental level, a higher proportion of women in fieldwork leadership roles could reduce barriers for other women. Many of the strategies developed here may be transferable and so help reduce barriers across marginalised groups [11, 20, 21, 26]. Fieldwork-specific extensions for institutional EDI policies [57] would provide an organisational baseline for home institutions and research stations. However, the effectiveness of institutional policies could be more limited in multi-institution or international collaborations without cross-institutional policy. One solution could be for funding agencies to require inclusive and equitable fieldwork policies from institutions.

The sexism, sexual harassment, violence, and psychological abuse raised by respondents highlights a need for broad cultural and institutional changes. The lack of accountability for these actions, exacerbated by the role of power structures and hierarchies, shows a need for improving institutional structures for reporting incidents and holding perpetrators to account. Such processes should be accessible, transparent, and fast, avoid retraumatizing the victim, and precipitate retribution. These institutional reporting structures should be available during (where possible) and after fieldwork and include independent, trained points of contact. Harassment should be treated similarly to research misconduct and safety policy infringements [37]. In addition, training should be provided on issues such as harassment, violence, and bullying; that is, ethical and respectful field conduct. All research team members should undergo the same training to tackle existing power dynamics and imbalances.

Institutional and team-based codes of conduct are another foundational step with impact through all stages of the fieldwork process. A code of conduct would remove ambiguity regarding acceptable behaviour in the field, build in accountability for misconduct, and reduce risks [58]. For example, APECS has specific templates for a Code of Conduct and Bill of Rights for polar fieldwork available [59]. The APECS code of conduct states mechanisms such as: identification and definition of appropriate and inappropriate behaviour, details on reporting and investigative procedures, inclusion of protection against retaliation, and built in mechanisms for evaluation and revision.





**Fig 4. Summary of strategies to navigate the improvement of women's polar fieldwork experiences throughout the different phases of fieldwork, based on the outcomes of the survey.**

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Women's fieldwork experiences could be improved and barriers to participation could be reduced by focusing on the following actions during the fieldwork process (summarised in Fig 4):

### 1. Improve pre-fieldwork preparation and communication

Many of the issues raised could be addressed by improving pre-fieldwork preparation and communication. Although we acknowledge that the nature of fieldwork can preclude advanced planning, pre-fieldwork preparation and communication should begin at least six months in advance where feasible [37]. Preparation includes setting clear work expectations and assigning specific field roles, as well as preparation and communication of 'non-scientific' fieldwork aspects, such as those identified by survey respondents (Table 1). For example, communicating the toileting situation (*i.e.*, access to toilets, privacy, lack of toilets or sheltered areas, and waste management practices) can minimise pre-fieldwork concerns [60]. Best practices for dealing with menstruation, which has previously been identified as a barrier to participation in remote fieldwork, should be included in safety briefings. Open discussions with all participants can identify factors that may have otherwise gone unaddressed. Where possible, the ability to submit questions anonymously could be beneficial. Structured and informal discussions with all participants early on can then shape more formal pre-fieldwork checklists.

Pre-fieldwork checklists are a simple but effective approach to help create a safer fieldwork environment and should be standard practice. Checklists should be provided well in advance of fieldwork, and can be developed using existing frameworks as templates, such as those within Ackerman et al. [37] and INTERACT field guides [61]. Checklists should be particular to each unique field excursion and based on feedback from pre-fieldwork communications with participants and previous post-fieldwork evaluations.

In addition, codes of conduct and training on issues such as harassment should be included in fieldwork planning [62]. One example is the Code of Conduct of Toolik Field Station,

**Table 1. Table of fieldwork aspects (excluding scientific activities) identified through this survey to be addressed in a pre-fieldwork briefing.**

Aspect identified in the survey	References for further reading	Recommendation
Safety equipment in the polar environment	Rasch et al., 2019 [61]	<ul style="list-style-type: none"> <li>Participants should all be familiar with the safety equipment in advance, including an opportunity to interact and 'test' the equipment.</li> </ul>
Appropriate field clothing	Johannesen et al., 2022 [64] Nash et al., 2019 [10]	<ul style="list-style-type: none"> <li>All clothing should be properly fit women's bodies.</li> <li>Effort should be made to design any new clothing with women's bodies in mind.</li> </ul>
Living arrangements		<ul style="list-style-type: none"> <li>Ensure participants are aware of living arrangements in advance.</li> <li>Provide options for input of preferences for roommates (e.g. gender preference, or request to share/not share with a specific person).</li> </ul>
Communication with family	Jones & Benedixen, 2022 [65] Kerr & Stewart, 2020 [30]	<ul style="list-style-type: none"> <li>Ensure awareness of communication options with family, e.g. if there is no phone coverage.</li> <li>Reasonable expectations of communication potential should be set and agreed upon in advance.</li> <li>Discuss possibilities to combine fieldwork and family life/care responsibilities.</li> </ul>
Team dynamics	Karplus et al., 2022 [66] Campbell et al., 2013 [17] Tuckman & Jensen, 1977 [67]	<ul style="list-style-type: none"> <li>Training on managing group dynamics is provided and compulsory for leaders.</li> <li>Ensure workload expectations (both overall and individual) are set and agreed upon in advance.</li> <li>Discuss equal distribution of traditionally gendered roles and ensure their equal distribution, such as cooking and cleaning of shared areas but also responsibilities within the field.</li> </ul>
Psychological/mental health	John & Khan, 2018 [68] Leon et al., 2011 [69] Sandal et al., 2006 [29]	<ul style="list-style-type: none"> <li>Ensure adequate personal space and downtime is provided.</li> <li>Participants should be encouraged to speak up if they have a mental health concern before the trip so that it can be accommodated.</li> <li>Discuss the potential challenges within the field and possible health challenges</li> </ul>
Provisions for any known physical disabilities or chronic conditions	Chiarella & Vurro, 2020 [70]	<ul style="list-style-type: none"> <li>Fieldwork plans should have inherent flexibility to ensure that disabilities and chronic conditions can be accounted for as much as possible.</li> <li>Participants should feel secure to disclose any conditions they have to field leaders.</li> </ul>
Local community engagement and dialogue	Sjöberg et al., 2019 [71] Arctic Council, 2019 [72] Callaghan et al., 2020 [73] Doering et al., 2022 [74]	<ul style="list-style-type: none"> <li>Make the effort and reach out to communities before arriving.</li> <li>Build mutually beneficial research relationships.</li> <li>Create a dialogue to address issues in a joint effort.</li> <li>Address flaws in institutional and/or funding systems regarding equal participation in research</li> </ul>
Weather conditions	Kadir et al., 2013 [75] Leidman et al., 2020 [76]	<ul style="list-style-type: none"> <li>All fieldwork participants should be aware of and prepared for all possible weather conditions.</li> <li>Discuss tools used to ensure fieldwork is carried out in safe manner considering weather prospects.</li> <li>Manage expectations regarding weather conditions.</li> </ul>

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Alaska [63]. Finally, specific deployment training (*i.e.* simulation of the field environment to ensure that participants understand how to use scientific and field equipment prior to departure) should be standard practice.

## 2. Improve practices during fieldwork

Many of the issues leading to negative fieldwork experiences could be resolved by implementing standards antecedently. The field team leader should ensure personal space, toilet breaks, and sufficient rest periods are incorporated into fieldwork. The leadership style should be proactive and flexible, with the capacity to alter the field plan to suit the team and conditions. A strong team dynamic should be fostered in which participants are encouraged to check-in on each other (e.g. a buddy system) and advocate for each other. Team members should be encouraged to speak up when observing a practice or behaviour that is unsafe, inappropriate, or dangerous, both from a mental and physical health standpoint (*i.e.*, speaking up about a team member having exposed skin and potentially getting frostbite, as readily as advocating

for a team member being bullied) and/or go beyond physical capability (*i.e.*, river crossings, steep and/or complex terrain).

Remote fieldwork, particularly in harsh conditions, can take a toll on mental and physical health [29]. During fieldwork it is important to promote and practise self-care for participants, including taking time off when resources and weather permit [77]. Involving local communities and developing local connections could reduce isolation, assist in maintaining mental well-being, whilst also increasing environmental safety through expertise of local conditions [62]. Sustainable local connections, in which the local community is involved in all fieldwork stages (planning, executing, and debriefing) also promotes decolonisation of the research enterprise and the promotion of CARE principles [78], equitable cross-cultural understanding, benefit sharing, and informed interpretation of findings [62].

### 3. Improve post-field communication

Poor post-field communication was consistently raised as an issue, particularly regarding a lack of de-briefing on non-technical issues such as team dynamics. Post-fieldwork debriefs should be standard practice and should be an open, safe environment for team members to discuss concerns. Debriefs can help prevent unsafe or exclusive spaces caused by inadequate communication and group awareness [56]. For multi-day fieldwork, daily debriefs are an important tool to ensure any issues do not escalate or continue, and that measures set up during fieldwork preparation are being followed. Depending on the team and the dynamic there is value in having group debriefs as well as one-on-one debriefs [56]. A group debrief in conjunction with standardised written evaluations that have the option of providing anonymous feedback is recommended.

## 5. Conclusion

This study presents the experiences of women taking part in polar fieldwork, spanning diverse backgrounds, ages, and research disciplines. By collating the lived experiences through an online survey, alongside a literature review, we aimed to develop a nuanced understanding of predominant factors influencing the physical and mental well-being of female researchers conducting remote fieldwork within the polar research community. We determined that the majority of survey respondents had encountered adverse fieldwork experiences attributable to various factors throughout their career. Our synthesis of dominant themes delivers focal points for targeted adaptation measures in fieldwork planning and execution. Some analysed issues, such as communication and debriefing, are not exclusive to one specific minority or group but reflect generic shortcomings in academia. Other barriers, such as harassment and power dynamics, are more likely to be experienced by minority and/or vulnerable groups and not the polar community as a whole. Nonetheless, following the steps/strategies suggested in this paper could improve the overall field experience of all polar researchers across the community.

Increasing participation and leadership of women in science will have positive effects for climate change research and subsequently global sustainable development. Through the framework delivered with this study, we also support further research and discussion in this field extending to other minority groups. A polar community equipped with multifaceted skills, knowledge, and passion will be able to address the urgent questions of today's climate science and facilitate knowledge sharing and solutions through diverse and gender-equitable research.

## Supporting information

**S1 Fig. Negative fieldwork experiences per age group.** The relationship between age group and percentage of respondents who have had negative experiences during fieldwork (n = 319). (TIF)

**S2 Fig. Reasons for negative fieldwork experiences per age group.** The relationship between age group and type of reason for negative field experiences ( $n = 265$ ). Twenty-three reasons could be selected in this multi-response answer (see S2 Text for the full list of reasons). Reasons were grouped into ten categories for plotting purposes, with percentages indicating the percentage of responses for each reason, per age group. Numbers above bars indicate the number of respondents per age group.

(TIF)

**S1 File.**

(TIF)

**S2 File.**

(DOCX)

**S1 Text. Methodology and records of the scoping literature review.**

(DOCX)

**S2 Text. Survey details.**

(DOCX)

**S3 Text. Demographics of survey respondents.**

(DOCX)

**S4 Text. Additional survey responses: Pre-fieldwork preparation.**

(DOCX)

**S5 Text. Additional survey responses: Post-fieldwork debrief and communication.**

(DOCX)

**S6 Text. Additional survey responses: Internal team dynamics and communication.**

(DOCX)

**S7 Text. Additional survey responses: Sexual harassment.**

(DOCX)

**S8 Text. Additional survey responses: Perceptions of future fieldwork.**

(DOCX)

**S9 Text. Survey Limitations and feedback from respondents.**

(DOCX)

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