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IMPACT OF THE COVID-19 CRISIS ON THE FRENCH ASTRONOMY COMMUNITY

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Abstract.
The world-wide Coronavirus Disease 2019 (COVID-19) pandemic spread in France from the beginning of 2020. This has led the government to implement lockdown and curfews and thus change work practices to limit the spread of the virus in the workplace and during commutes. In the field of research in astronomy and astrophysics and mainly during the first lockdown, researchers were encouraged or constrained to work from home, which impacted all their research activities (observations, conferences, experiments, teaching...). This unprecedented situation was likely to cause several negative side effects on the astronomical research community such as isolation, poor concentration, loss of motivation and meaning, mental health problems due to work-life imbalance and physical issues do to the inadequate home office space. On the other hand, the situation also had positive outcomes (reduction in the hectic pace of work, avoidance of travel time, increased family time, the convening of inter-laboratory seminars, access to international conferences for all...). In addition to these global effects, environmental and social factors may have also lead to different sensitivities from the crisis. To quantitatively and qualitatively assess the impact of the covid-19 pandemic consequences on our activities, we conducted a survey intended for the members of the French Astronomical Society of Astronomy and Astrophysics (SF2A). This paper presents an analysis of the 258 responses we received for this survey, specifically about the impact of the sanitary crises on the physical and mental health of individuals, professional relationships and workload, scientific production (e.g. publications and applications), and events that take place online (e.g. meetings and conferences). In particular, we identify groups of people particularly impacted by this crisis: women, precarious researchers, parents and expatriates. Based on these results, we also propose recommendations for the community to revive scientific interactions in the post-COVID-19 era while offsetting its most deleterious effects on vulnerable groups and maintaining its positive effects such as the consequent reduction of the carbon footprint of research.

Keywords: SF2A, socio-demographic survey, covid-19 pandemic, gender, parenthood, job security, early-career researchers

1 Introduction

The global coronavirus 2019 (COVID-19) pandemic spread in France from the beginning of 2020 and prompted various governmental decisions: three lockdowns (March 17-May 11, 2020; October 30-December 15, 2020; and April 3-May 3, 2021), curfews during and between lockdowns, border closures, interruption of social and cultural activities, significant changes in working conditions, long-term school and university closures, and shift to distance learning with limited childcare options. This situation had an impact on the health, work and personal lives of individuals, and astronomical research was not excluded.

Academy is a unique work environment with characteristics like long-distance work-related travels (mainly for field experiments, conferences and collaborations), short-term work contracts (3 years or less) sometimes in foreign countries, a significant amount of time spent applying for grants and job applications, as well as

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Table 1. Gender and position demographics of the survey participants.

Gender		Current position	
Man	62.8%	Permanent researcher or professor	59.3%
Woman	34.9%	Post-doctoral researcher	19.8%
Non binary person	0.4%	PhD candidate	10.9%
Not disclosed	1.9%	Engineer or technician	5.8%
		Master student	1.9%
		Emeritus	1.9%
		Other staff	1.1%

specific metrics to evaluate the research quality (e.g. number of peer-reviewed publications, amount of funding received, observation/computation time granted, responsibilities in large projects). Several studies about the impact of the sanitary crisis on research communities have been conducted so far, whose results point out the effect on gender inequities, particularly due to unequal work-life balance and children home-schooling. First of all, the lockdown impacted differently publication rates of men and women, with an increase for men and a decrease for women. If Viglione (2020); King & Frederickson (2021) conducted an overview of the publication gender gap due to the pandemic, this phenomenon has been measured in specific subfields or journals, such as in general health and medicine (Beverly 2021), in ophthalmology (Nguyen et al. 2021), in publications related to COVID-19 (Lerchenmüller et al. 2021), or in the Elsevier journals (Squazzoni et al. 2020). In particular, it has also been observed in astronomy within the Italian astronomical community by Inno et al. (2021). Among women, young career female scientists appear as a particularly impacted group (Gewin 2020), in addition with mothers and women of color: Staniscuaski et al. (2021) measured this gender- and motherhood-based effect in the Brazilians academic system and Fulweiler et al. (2021) points out the intersection with ethnicity and race. COVID-19 did not only impact publication rates, but also academic job stability, particularly for women (Gewin 2020), the access to permanent positions for mothers (Cheng 2020), mental health, particularly for women and post-doctorate researchers (Beverly 2021; Woolston 2020a,b).

In line with the studies led in other fields of research and/or countries, we aim to understand the impact of the pandemic on the French astronomical research community, which has its own scientific culture (e.g. academic system, career path, job opportunities). This motivated the survey and its analysis presented in this paper, where we intend to gauge the impact of the pandemic on the French astronomy research workforce and to emphasize the practices to maintain in the after-crisis era and the other to implement to counterbalance the negative side effects of the sanitary crisis.

This study is based on a survey intended for the French community of researchers in Astronomy and Astrophysics, aiming to grasp the impact of the sanitary crisis on the scientific production (e.g. number of publications, grant applications, observing/computing proposals) and well-being (e.g. work-life balance, interactions with colleagues, mental and physical health) during the COVID-19 crisis. This survey was made of 38 questions divided in different sections (general demographics, parenthood, physical and mental health, day to day working activities, scientific publications, applications, online events, professional interactions, and post-COVID-19 inclination) and communicated by the SF2A conference committee during the French Astronomy Week in June 2021. The survey can be read in the Appendix A. We gathered a total of 258 valid answers that we analyzed to collect the general characteristics of the respondents, presented in section 2, and to identify specific problematics to pay attention to and the most vulnerable groups based on demographic data (gender, expatriate situation, job stability, parenthood) (see section 3). From the results, in section 4, we formulate a set of recommendations to better prepare the post-crisis scientific activities, before concluding in section 5.

2 General demographics

The survey was open during and after the French Astronomical Society SF2A annual conference that took place virtually in early June 2021. Among the $\sim$ 700 SF2A members, we collected 258 answers to our survey. The table 1 summarizes some of the demographics of the respondents.

The respondents panel consists of 162 men, 90 women, one non-binary person, and 5 people preferred not to disclose their gender. The women ratio can be compared to other measures made on the French astronomical community, such as Bot & Buat (2020) (23% of female permanent researchers and professors in astronomy in France, 22% according to Berné & Hilaire (2020), and the ratio evolution is also studied

in Suarez (2021)), Pommier (2021) (22% of women in permanent position in astronomy in Europe), and `https://www.iau.org/administration/membership/individual/distribution/` (26% of women among the french IAU members). These percentages indicate that the survey panel over-gathers women respondents (a phenomenon already observed in Leboulleux et al. 2020) and the ratio of 34.9% should be taken with caution.

Table 1 also indicates the distribution of the participants among different professional positions. The main categories correspond to permanent researchers and professors (153 participants), post-doctoral researchers (51) and PhD candidates (28). The percentages of engineers, ITAs, and other staff members are clearly lower than the actual ratio in a French research institute, which is probably due to the fact that SF2A is mainly targeted at researchers. Belonging to one category or another has an impact on the experience of the covid-19 crisis, as it correlates with different situations such as job stability and with different age groups (Woolston 2020a; Webb 2021).

Among the respondents, 20.9% indicate working in a foreign country, 77.5% are working in France, and 1.58% preferred not to disclose. Expatriation can impact the personal experience of lockdown and COVID-19 crisis due to general isolation and mental vulnerability. It raises further challenges for expatriates including complex access and understanding of news and government decisions due to the language and media barriers, inability to meet family members and friends in their home countries due to travel restrictions and closed borders, home sickness, helplessness towards disparities between the gravity of covid-related events in their current country of residence and home countries, more complex access to medical facilities over the locals, and increased violence and racism due to misinterpretation of the covid-related events.

Among the respondents, 52.7% indicated they have no children, while 47.3% have at least one child. According to other studies, parenthood is also a discrimination criterion in academia, so we chose to take it into account and analyse it in this survey. Generally speaking, Cheng (2020) indicates that women with children are less likely than their male peers to ever obtain a tenure-track position and Berné & Hilaire (2020) discusses the gender-related impact of parenthood on the scientific performance for French researchers. Those effects were emphasized during the covid-19 pandemic: Crook (2020) describes parenthood in British academia during the Covid-19 pandemic, and Fulweiler et al. (2021) and Staniscuaski et al. (2021) focus on the impact of the crisis on scientific productivity and mental health of women and women of color with children. It should also be noted here that most parents are permanent staff (92.5% of parents are researchers, professors, emeritus, engineers or ITAs) and usually older than 30 years old (98.3% of parents are above 30 years old), which creates a correlation between different factors.

3 Observations and outputs

In this section, we present the main results of the survey, and we focus on the impact of the sanitary crisis on the individual physical and mental health (section 3.1), on the work environment and professional interactions (section 3.2), on the scientific production in terms of publications and applications (section 3.3), and on the virtual communication tools used to carry on working (section 3.4).

3.1 Physical and mental health

As of June 30 2019, more than 5.5 millions confirmed cases of Covid-19 infection have been reported in France*, which correspond to 8% of the overall population. As a comparison, 11.6% of the survey respondents have been hit by the virus with symptoms, 0.4% without symptoms (ie. one person), and 22.5% do not know if they got the virus.

As a side effect of the disease, the pandemic has had an impact on the physical and mental health of individuals. This is mainly due to the lack of an appropriate work setup (e.g. stable internet connection, ergonomic computer equipment, desk and chair, efficient computing power, separate room to work), the movement restrictions due to severe lockdown sometimes in small apartments (e.g. physical and cultural activities, holidays, family and friends interactions, social events with colleagues), the reduced access to medical care (e.g. virtual consultations with physicians, canceled surgery), and to the overall uncertainty, stress and anxiety due to the global situation and affected family members and friends. Figure 1 presents the feedback of the respondents on the impact of the sanitary crisis on their physical and mental health. In terms of physical health, 60% of the respondents declare a slight to very negative impact, 24.4% declare no impact, and 15.5% declare a positive

*www.santepubliquefrance.fr

impact. In terms of mental health, 65.6% of them declare a slight to very negative impact (skewed to very negative), 17.4% declare no impact, and 17.1% felt a slight to very positive impact. This shows that the sanitary crisis seem to present a more negative impact on mental health. Expatriates are the most concerning category, with more than 70% of slight to very negative impact (18.5% very negative, 25.9% negative, 25.9% slightly negative). Parents are less but still very affected (49.8% of negative impact, mostly slightly negative), probably partly due to a lower social isolation and a correlation with the fact that most parents occupy permanent positions that decreases their stress due to an uncertain future or prompt moving, even if other sources of stress (home-schooling, children future...) remain. Indeed, in terms of job position, the most vulnerable categories correspond to the post-doctoral researchers (72.5% of slight to very negative impact, including 25.5% of very negative impact) and the PhD candidates (89.3% of slight to very negative impact, including 17.9% of very negative impact), in addition with the master thesis students (all 3 students declare slight from very negative impact on their mental health). Eventually, no clear trend could be identified in terms of the gender of the participants. It should be noted here that some of the mentioned categories are correlated, which makes the identification of stress causes complex. For instance, 76% of expatriates are non permanent staff and only 14% of parents are expatriates.

Finally, we measure the feeling of isolation among participants: overall, 45.7% answered they felt isolated during the lockdown and 51.9% answered they did not. The most concerned categories are, once again, expatriates (63.0% felt isolated), PhD candidates (75.0%), and postdoctoral researchers (64.7%).

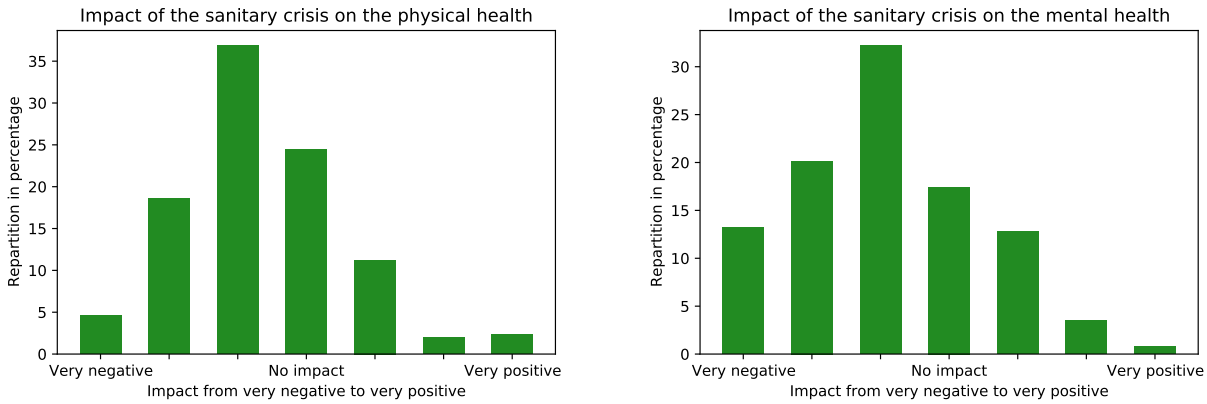

Fig. 1. Qualitative impact of the sanitary crisis on the physical and mental health. **Left:** Histogram of participant answers to the impact of the sanitary crisis on their physical health. **Right:** Histogram of participant answers to the impact of the sanitary crisis on their mental health.

3.2 Work environment

Due to lockdown and isolation, teams and collaborators could not meet and all social and professional interactions shifted to online meetings and email discussions. This evolution impacted the relationships between colleagues and collaborators. Fig. 2 (left) illustrates this effect: 82.8% of participants felt their professional relationships evolved negatively, 11.8% felt no evolution, 5.3% felt they improved. Informal discussions on professional or various topics were almost reduced to zero (no more common lunch time or coffee breaks), although these convivial conversations are essential to exchange even casual information within a group, or discuss and generate new ideas, even if some of these discussions shifted online.

In particular, a sane student-supervisor relationship is crucial to maintain since it corresponds to a strong hierarchy between individuals from the most and the least vulnerable groups. The survey indicates that this relationship follows the trend of the general professional relationships, with a better perception from the student perspective (60.4% felt a negative impact, 32.1% no impact, 7.55% a positive impact) than from the supervisor one (81.8% felt a negative impact, 13.5% no impact, 4.71% a positive impact).

The survey also collected the feeling of the participants towards the evolution of the workload with the sanitary crisis. As illustrated on Fig. 2 (right), 6.7% of participants felt their workload decreased with the pandemic, 36.5% felt no impact, and 57.3% felt an increase of their workload.

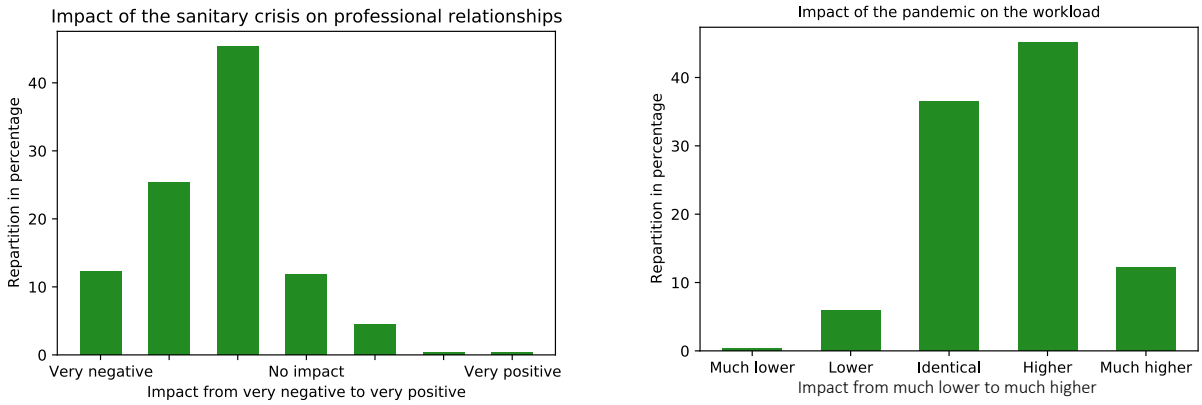

Fig. 2. Qualitative impact of the sanitary crisis in the work environment. **Left:** Histogram of participant answers to the impact of the sanitary crisis on their relations to colleagues. **Right:** Histogram of participant answers to the impact of the sanitary crisis on their workload.

3.3 Scientific production

While we acknowledge that the number of publications does not reflect the scientific quality and productivity of a researcher, this metric has been used in other fields as an indicator to assess the impact of the pandemic on research and and is also often taken into account for career development when it comes to hiring, promotions or grants. In particular, various articles have measured the differential publication rate between men and women during the sanitary crisis, pointing out a gender-based inequity in facing work-life balance challenges, with more resources for men and more mental, home, and family load for women. In particular, it has been shown that with the lockdown, publications by men have increased while publications by women have decreased (Kreeger et al. 2020; King & Frederickson 2021; Squazzoni et al. 2020; Lerchenmüller et al. 2021; Mahmoudi 2021; Nguyen et al. 2021; Staniscuaski et al. 2021).

Similarly, the survey participants provided their number of first author publications in 2019 and 2020. We put a threshold at 10 and computed the average number of publications per year, visible in Fig. 3 (purple columns, identical in the three plots). The average number of publications decreased by 1.36% between 2019 and 2020, which is negligible. However, this evolution depends on the participant category: if we consider the participant gender, men publication rate increased by 4.89% while women publication rate decreased by 8.79%, and we can also notice that in 2019 women already tended to publish less than men (see Fig. 3 top left). Expatriates tend to publish more than non-expatriates and their publication rate increased by 7.36% while it decreased by 4.42% for non-expatriates (see Fig. 3 top right). Similarly, parents tend to publish slightly more than non-parents, but their publication rate decreased by 11.4% between 2019 and 2020 while it increased by 9.85% for non-parents (see Fig. 3 bottom). In terms of status, PhD, postdoctorate, and emeritus researchers saw their publication rates increase (78.6%, 37.2%, and 13.3%), permanent researchers and professors saw it decrease (10.6%), and engineers did not change their publication rate. This can once again be related to the fact that permanent researchers tend to have children at home, while young career researchers do not, most of them even living alone.

In addition to the number of publications, the number of grant and job applications can be insightful: they impact the scientific productivity and so the long-term career, and are an indicator of the job stability. Therefore, the impact of the pandemic should be measured and taken into consideration to adapt the system to the situation (Oleschuk 2020).

In the survey, we measured the evolution of the average number of grant proposals (NP, ANR, ERC, etc.), of job applications (postdocs, fellowships, tenure tracks, permanent positions, etc.), and of proposals for observing time and supercomputing time. Fig. 4 shows that grant proposals increased by 3.62%, job applications by 10.8%, and observation and heavy simulation time proposals decrease by 10.8%. The increase of job applications shows a lack of confidence in the future and a high instability of the job market, while the decrease of observation and simulation times is probably due to the shutdown of several telescopes during the lockdown. Once again, these evolutions depend on the participant category and particularly affected women (+19.7% of job applications and −22.1% of observation and simulation tool proposals, vs +6.41% and −4.93% for men).

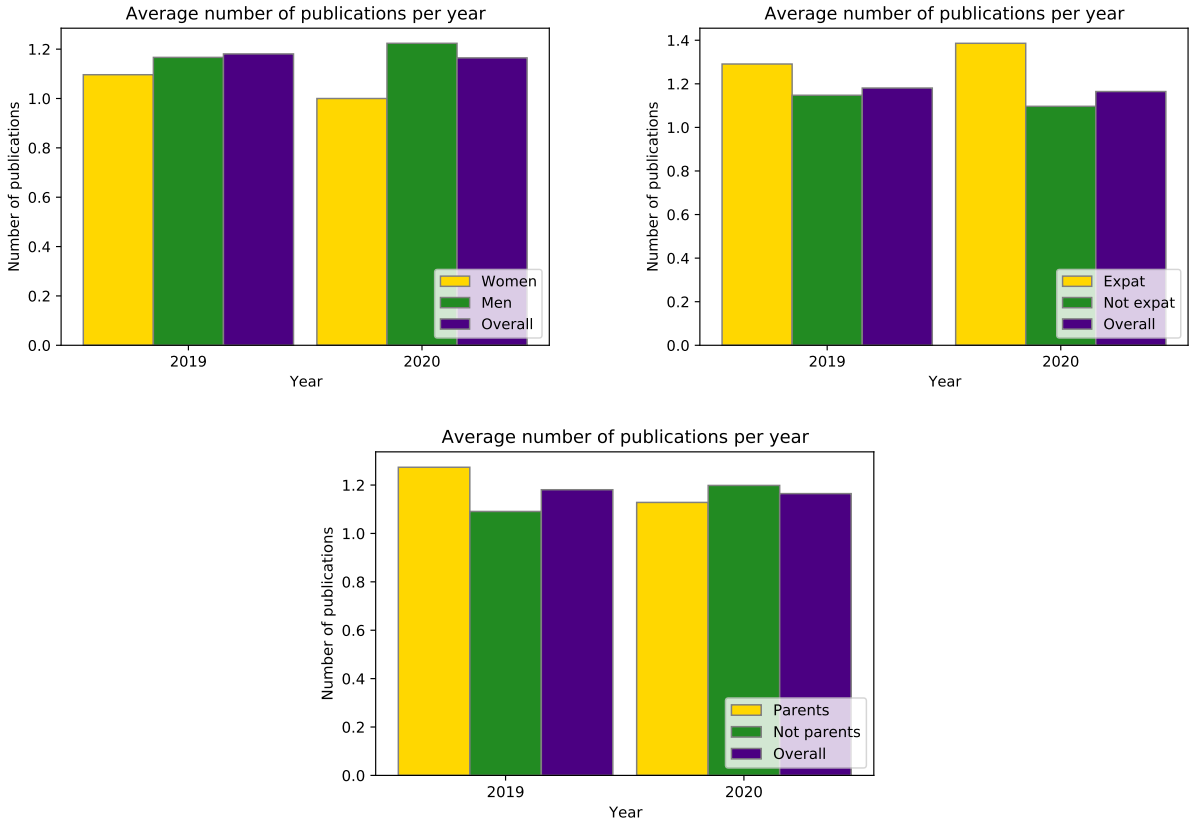

Fig. 3. Number of first author publication in 2019 and 2020 for different categories. **Top left:** Average number of publications in 2019 and 2020 for women (yellow), men (green), and overall (purple). **Top right:** Average number of publications in 2019 and 2020 for expatriates (yellow), non-expatriates (green), and overall (purple). **Bottom:** Average number of publications in 2019 and 2020 for parents (yellow), non-parents (green), and overall (purple).

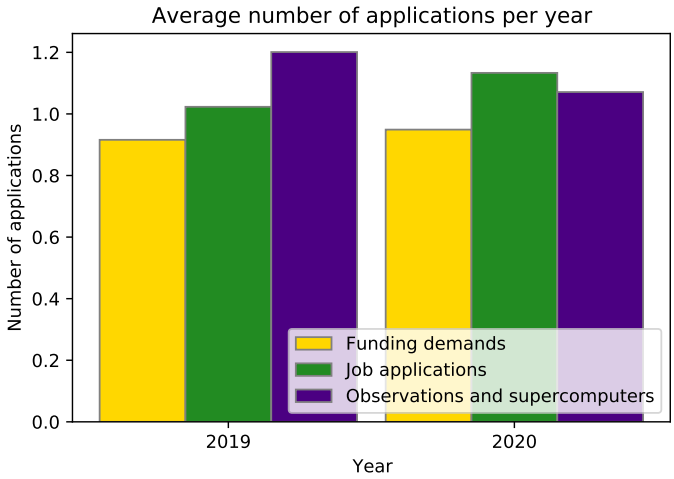

Fig. 4. 2019 and 2020 average numbers of funding demands (yellow), job applications (green), and observation and supercomputer simulation time proposals (purple).

Overall, 65.1% of concerned participants felt the Covid-19 crisis had a slight to very negative impact on their scientific production, 24.2% felt no impact, and 10.7% felt a positive impact on their scientific production.

3.4 Communication

Another effect of the pandemic on the astronomical research community is the cancellation of meetings, seminars, workshops and conferences. They were often replaced by online events based on tools that were sometimes used beforehand (Zoom, BigBlueButton, Gathertown...), in an effort to keep teams unified despite the pandemic and the distance. These many changes made it difficult to track the number of events, but survey participants were given the opportunity to share their feelings about the number of events online, plotted on Fig. 5 (left): 6.72% of them think there were too few events, 36.0% think there were enough events, and 57.3% think there were too many events.

This feeling of being overwhelmed by the number of online events echoes what has been called "zoom fatigue", i. e. the difficulty to focus for a long time during online events. Fig. 5 (right) indicates how this zoom fatigue has been experienced by the community: 68.9% reported an issue with concentration, 20.2% were not impacted by the switch to online events, and 10.85% prefer this new form of communication.

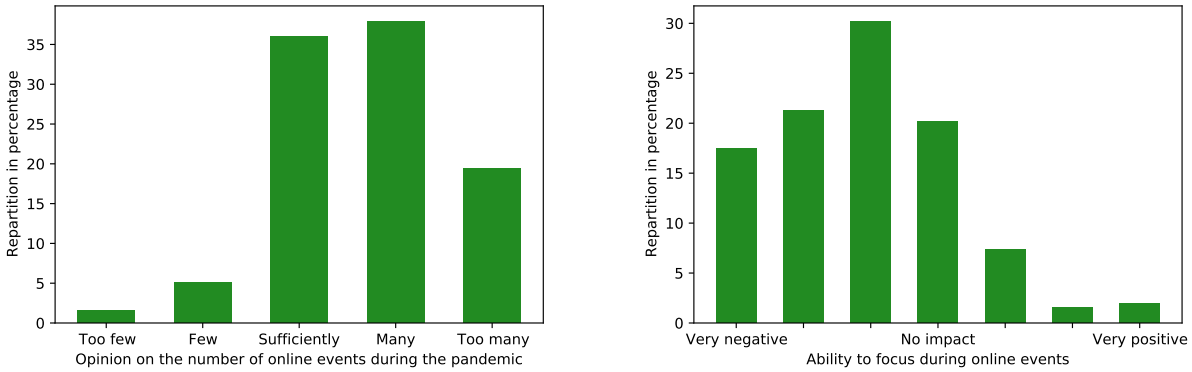

Fig. 5. Qualitative feeling about online events during the sanitary crisis. **Left:** Histogram of participant answers to the number of online events during the pandemic. **Right:** Histogram of participant answers to their ability to focus during online events (or zoom fatigue).

4 Recommendations of actions to be taken

To most people, the pandemic is experienced as a trauma and should be considered as so by institutions and individuals. This trauma is personal but also professional since it will have a long-term impact on careers, in particular for the following categories of people: non permanent researchers (PhD candidates and postdoctoral researchers), women, expatriates, and parents. These categories already suffer from discriminations in the field of astronomy that increased with the pandemic. Efforts to create a benevolent, diverse, and inclusive community should increase to compensate for the effects of the sanitary crisis.

These efforts need to be undertaken at different scales and in this section we provide some examples of actions that would support individuals, especially the most vulnerable ones, during and after the pandemic. We acknowledge the implication of the survey participants who proposed some of the recommendations below. Some actions have also been formulated in other articles for other fields of research (Gewin 2020; Kreeger et al. 2020; Oleschuk 2020; Fulweiler et al. 2021; Staniscuaski et al. 2021; Woolston 2021), and some have already been put in place, showing a high implication and support from laboratories during the crisis.

- **Individual well-being:** This pandemic had a high impact on mental health and well-being, particularly for precarious and expatriate people (see Fig. 1). We encourage to not assume or negatively judge one other experience and reaction to the crisis since they can be impacted by numerous factors. A psychological support would help some individuals, in particular PhD candidates who are highly vulnerable and can hardly afford one by themselves.

- **Student-supervisor relationship:** The frequency of interactions, preferably on-site instead of online, could be temporarily increased to maintain or rebuild a stable relationship. Clarifying without increasing

expectations would also enable to minimize stress for all. In addition, educational activities can be organized, dedicated to both students and supervisors: to students concerning workload, rights, or mental health, and to supervisors to raise awareness towards mental health, vulnerability, or difficulties faced by under-represented groups.

- **Team building:** Maintaining a social link within a team is particularly crucial for vulnerable individuals or to welcome new team members. It can be done with dedicated communication channels (for instance Slack) and/or a virtual chat room open at any time for frequent informal exchanges or coffee breaks.

- **Administrations:** The instability of the situation and the variations of governmental constraints can be complex to apprehend, mainly for non-french speakers. Individuals could be helped by a clarification of rules by lab administrations or team managers. Support from administrations and institutions would also help precarious individuals to stay at home despite an opposite wish from the supervisor, or to reallocate fundings, duties and services.

- **Hardware and software work conditions:** All individuals do not have proper or equivalent work conditions at home. Young-career researchers tend to live in a one to two room apartment, without an optimal work material such as a wired connection, a large screen and a comfortable chair and desk. Help from the institute to check the access to research resources, provide proper tools, and optimize home-office conditions is greatly appreciated. In addition, an access to particular software tools dedicated to work, teaching, or social interactions would help home-working people.

- **Home-office:** If people were not used to home-office before the pandemic (63.6% of survey participants were never home working, see Fig. 6), they are willing to modify this habit: only 14.3% of people wish to remain fully on site, and the majority prefers to work from home between one and three days a week.

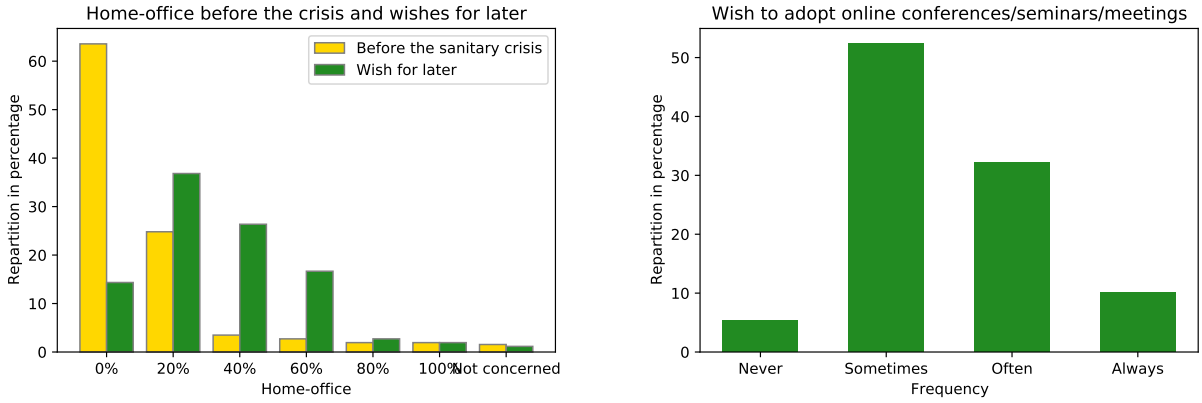

Fig. 6. Change of habits regarding teleworking and online events. **Left:** Histogram of participant answers to their fraction of home-office before the crisis (yellow), and their whishes for later (green). **Right:** Histogram of participant answers regarding their wish for the frequency of online events after the crisis.

- **Workload:** People generally felt their workload increased during the pandemic (see Fig. 2), with longer and more frequent meetings, longer preparations for teaching duties, and a different work-life balance (domestic labor, children home-schooling, eldercare, etc.). Individual workloads within small teams or projects could be maintained below a certain threshold and adapted to each one's living conditions. For instance, there could be an identification of supports to partially reallocate teaching duties and services from people with caregiving demands or junior researchers to colleagues with more flexibility.

- **Privacy respect:** In addition with the previous point, the workload and meetings should not exceed conventional work hours. This would limit work-life mixing and minimize negative effects on mental health, but it would also enable parents to participate to conferences and meetings without having to leave and miss events or information. It is also crucial to take into account the fact that people can be attached to different time zones when organizing online events, which could lead to shortening events.

- **Online events:** Even if survey participants felt generally overwhelmed by the number of online events and by the zoom fatigue (see Fig. 5), they are in huge majority willing to maintain some online events after the sanitary crisis (5.43% of participants refuse online events, 52.3% wish to adopt them sometimes, 32.2% often, 10.1% always, see Fig. 6). The selection could be done on the duration of the event (one-day or shorter events gathering people from different regions or countries can be done online), on the audience (the implication of new members among a network is easier if face-to-face), or hybrid options can even be considered: alternating online and on site events or proposing an online option to all face-to-face events. To fight zoom fatigue and the increased number of events, it is also important to select most necessary events and to focus on the planned topic and program.

- **Online event tools:** In addition to Zoom, different online event platforms have been made possible, with various security options, and should be advertised: BigBlueButton, MS Teams, Jitsi, Element/Matrix, or Renavisio. CarbonFreeConf[†](Kral 2021) also consists in a unique platform gathering multiple tools for a complete online conference with a Carbon compensation.

- **Meetings:** In addition to what has been proposed above, for online meetings (except for very large events) the camera could be turned on to facilitate interactions and face recognition. Seeing faces also help people with some disabilities. For privacy purposes, some online meeting tools even enable to blur backgrounds.

- **Conferences and seminars:** The pandemic has proven the possibility to organize online workshops and conferences at very different scales. As a side effect, these events have very lower Carbon footprint and financial cost than on site events, which can encourage young-career scientists or individuals with no financial support to attend them. It can also motivate people with disabilities and parents that avoid having to find an accommodation for their children. Therefore, we encourage online options to be developed even for on site conferences, possibly divided in half days instead of full days to avoid zoom fatigue and to remain open to several time zones. However, informal moments (coffee breaks, session gaps, evenings, etc.) could be maintained and adapted. Platforms like Gathertown can also be taken advantage of to maintain these social interactions despite the distance. A few on-site conferences, more rare, could also be kept when considered as not fully replaceable by online events.

- **Parenthood:** Due to school closures, parents have been highly impacted by the pandemic. It is important to acknowledge their situation and work conditions by increasing duty and deadline flexibility, removing the caregiving stigma, removing or reallocating some services, in particular when non essential (editing, reviewing, some teaching or night observations...) between colleagues, and remaining benevolent when confronted to colleague parenthood-due situations (children in meetings or conferences, task delay, etc.). Including parenthood status in activity reports and applications would also enable to reduce the discrimination they tend to face, mainly for women and young-career scientists.

- **Teaching:** During the lockdowns, online teaching has been negatively experienced by both students and professors and would better be avoided as much as possible. In addition, as mentioned above, during a lockdown, a reduction or redistribution of the teaching duty could be helpful for staff members encountering difficulties managing their duties, for instance when they have children at home.

- **Publications:** With the impact of the crisis on publication rates, in particular for vulnerable groups, journal editors have a crucial role in counterbalancing the long-term effect of the pandemic. Solutions could be to reduce fees for young-career scientists and women, to invite women, parents, and early-career researchers to write review articles, and to prioritize submissions from vulnerable groups, while extending deadlines for reviews and revisions.

- **Job market:** 2020 and 2021 have been a very unstable period for career opportunities and fundings, mainly for women (see Fig. 4). As already implemented in some institutions, a first solution consists in to systematically extend short-term contracts (PhD candidates, postdoctorate researchers, etc.) to provide a stable environment during the crisis, for instance since moving opportunities have become complicated with the border closure.

[†]https://www.carbonfreeconf.com

- **Proposals and applications:** To compensate for the effect of the pandemic on under-represented and vulnerable groups, offer vocabulary could be modified to be more inclusive to parents, women, non-binary people, and young-career scientists. In addition, these groups could be encouraged and supported by their institutions with possible mentoring to apply for positions, promotions, fellowships, grants, and prizes. Eventually, extending pr postponing deadlines (for non-essential scholarships) by a few months to a year would let people the most affected by the crisis apply safely. Eventually, some grants could specifically target under-represented groups like women, expatriates, young-career scientists, or parents.
- **Evaluation committees:** Funding organizations and evaluation committees could also consider or continue considering disparities between individuals during the crisis and more generally in the field. This requires shifting institutional norms and updating evaluation criteria to include under-represented groups, for instance by acknowledging other activities (teaching, outreach, implication in social activities, parenthood, etc.), mainly when judging 2020 and 2021 scientific performance (see the COVID-19 CV Matrix in Arora et al. (2020)). The jury can also set quotas for fundings, prizes, hirings, and leadership positions. Eventually, boards themself should be as diverse as possible, with at least 30% of women.
- **Learn from the pandemic:** measuring the impact of the pandemic and its side effects on the astronomical research community, in particular on underrepresented groups, is crucial to understand its trauma and improve its recovery, the well-being of its members, and the robustness of the community to possible future crises. This requires feedbacks from individuals to their laboratories and institutions, surveys, data collections and analyses like this one at different scales, and output spreading.
- **Sharing experiences:** A last recommendation we wish to formulate is the importance of sharing our experiences of the pandemic. The COVID-19 experience has been unprecedented so far and has a huge impact on isolated people. Many people have doubted themselves, questioned their own reactions to the situation. However, the problem has never been individual but global. It is time to share our experiences and see that each of us has never been alone. Several ways of communication could be used, such as a safe zone professional groups in institutions, Slack with a dedicated channel for vulnerable groups, or dedicated sessions in conferences.

5 Conclusions

In this paper, we have presented some of the effects of the pandemic on the french astronomical research community, collected with a survey conducted among the SF2A society. Concerning health, the most dramatic result concerns mental health and isolation, with 65.6% of participants negatively impacted by the pandemic, meanly PhD candidates and postdoctorate researchers. The lockdown also negatively affected professional relationships (82.8% of participants felt a negative evolution) and increased the workload of participants (57.3% felt an increase of the workload), particularly problematic during this year of mental isolation and uncertainty, combined with an increase of the family care for parents. The scientific production have also been impacted by these disturbed work conditions, number of publications evolving differently with the gender, the parenthood and the expatriation. The job market also appears highly unstable (+10.8% of job applications between 2019 and 2020), particularly for women (+19.7%), as did the demands of access to observations and supercomputer resources (−10.8% overall, −22.1% for women). Eventually, with the switch to online events (meetings, seminars, workshops, conferences), several side effects appear : the zoom fatigue (experienced by 68.9% of participants), ie. the difficulty to focus in front of a screen, and the feeling of too many events, some of them having been pointed out as useless or unefficient.

All categories have not been impacted equally by these different effects, and under-represented or vulnerable groups are particularly victims of the pandemic: women, expatriates, parents, and precarious individuals (PhD candidates and postdoctorate researchers). A special attention should be brought to their work conditions when looking for solutions to compensate for the effect of the crisis on research and careers and to go on improving the community environment. This is taken into account in the actions we propose in this paper, which focus on the overall wishes of the community (partial switch to online events, home-working...), on the well-being of all community members (team building, formations, work conditions...), and on equity in terms of scientific production and access to positions, grants, and tools. We acknowledge that several of the actions we mentioned have already been put in place thanks to high support and flexibility of many institutions or organizations.

Some of the recommendations should have positive side-effects. First, as mentioned earlier, they should create a more diverse and inclusive community, under-represented and vulnerable groups having been particularly

impacted by the pandemic. For example, switching some events online should increase the access to conferences for more people, like young-career researchers with less financial resources, parents who do not need to find childcare accommodations, people with physical or other disabilities, etc. Modifying success criteria, defined for an outdated traditional research workforce (white people, men, non-disabled people...) and prioritizing under-represented groups for applications and publications can only make the community overall more diversed and inclusive. Another side-effect of these recommendations is their impact on the environment, in a period where the climate crisis imposes a fast and efficient ecological transition for all activities, including research (Cantalloube et al. 2020; Ligozat et al. 2020; Stevens et al. 2020; Zwart 2020; Mariette et al. 2021; Glausiusz 2021). The academic activity has a particularly high carbon footprint due to air travels (conferences, meetings, on-site observations) and the community wish to partially switch to online events will reduce its carbon footprint.

Some limitations of our study can be pointed out. In particular, more factors than gender, parenthood, expatriation, and precarity impact the COVID-19 experience, like race and ethnicity, and mental and physical disabilities (Crook 2020; Oleschuk 2020; Fulweiler et al. 2021; King & Frederickson 2021; Staniscuaski et al. 2021). Some intersecting factors should also be considered: on other studies (fields and/or countries), mothers and black women are by far more impacted by the pandemic than fathers and other gender and race categories. In addition, to measure the effect of the crisis on the scientific production, Inno et al. (2021) mentions considering only publications from March to May, where the lockdown was the hardest and the knowledge on the virus was the most uncertain. Given these remarks, the study we present here could and should be improved in the future, even if we recommend to later focus on developing solutions, compensations, improvements, and adaptations, at all the community scales (individuals, teams, laboratories, collaborations, national organizations, journal editions, etc.).

A Survey: Impact of environmental/social factors on scientific production during the covid-19 pandemic

We propose this survey, intended for the French community of researchers in Astronomy and Astrophysics, in order to better grasp the impact of the sanitary crisis on the scientific production (number of publications, grants application etc.) and well-being (work-life balance, relationship with colleagues etc.) during the covid crisis. The aim of this survey is to better prepare the post-covid scientific activities under the constraints given by the pandemic situation.

- **Demographic information:**

  1) Gender

     (Woman/Man/Non binary person/Other/Prefer not to disclose)

  2) Are you an expatriate?

     (Yes/No/Prefer not to disclose)

  3) Age range

     (Less than 20/21-25/26-30/31-35/36-40/41-45/46-50/51-55/56-60/61-65/More than 66)

  4) Current position

     (Master thesis student/PhD candidate/Postdoctorate researcher/Permanent researcher or professor/ Emeritus/Engineer and ITA/Other staff)

  5) Year of doctoral graduation

     (All options until 2021/Not concerned/Prefer not to disclose)

  6) Number of dependent children

     (0/1/2/3/4/More than 5)

- **Parenthood:**

  7) How many days of parental leave did you take in 2019 ? (excluding parental leave after birth)

     (0/1-5/6-10/11-15/16-20/More than 20/Not concerned)

  8) How many days of parental leave did you take in 2020 ? (excluding parental leave after birth)

     (0/1-5/6-10/11-15/16-20/More than 20/Not concerned)

9) Did you receive assistance and support with childcare during lockdowns/school closures? (partner, parent etc.)

(Yes 100%/Yes 75%/Yes 50%/Yes 25%/No/Not concerned)

- **Health (physical and mental):**

10) Have you contracted the coronavirus?

(Yes with symptoms/Yes without symptoms/Do not know/No)

11) What is the impact of the covid crisis and of home-office on your physical health (more physical activities, more or less back pain, joint pain, circulation problems, more or less migraines / headaches, vision problems etc.)?

(Very negative/Negative/Somewhat negative/No impact/Somewhat positive/Positive/Very positive)

12) What is the impact of the covid crisis on your mental health (more sleeping time, more personal time, less stress, insomnia, anxiety, burn-out, depression/breakdown)?

(Very negative/Negative/Somewhat negative/No impact/Somewhat positive/Positive/Very positive)

13) Did you feel isolated during the confinement?

(Yes/No/Prefer not to say/Not concerned)

- **Day to day working activities:**

14) Did the lockdown prevent you from performing critical tasks for your research (access to optical benches, experiments, observations)?

(Not at all/A little/A lot/Very much/Completely/Not concerned)

15) How do you feel about the workload during the health crisis compared to before?

(Much higher/Higher/Identical/Lower/Much lower/Not concerned)

- **Scientific publications:**

16) Number of publications in 2019 (peer-reviewed and SPIE proceeding, as a 1st author)

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

17) Number of publications in 2020 (peer-reviewed and SPIE proceeding, as a 1st author)

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

18) How do you feel about the impact of the health crisis on your scientific production?

(Very negative/Negative/Rather negative/No impact/Rather positive/Positive/Very positive/Not concerned)

- **Applications:**

19) How many grant proposals have you submitted (NP, ANR, ERC, etc.) in 2019?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

20) How many grant proposals have you submitted (NP, ANR, ERC, etc.) in 2020?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

21) How many job applications have you submitted in 2019 (post-doc, fellowship, tenure track, permanent position...)?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

22) How many job applications have you submitted in 2020 (post-doc, fellowship, tenure track, permanent position...)?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

23) How many proposals for observation time, simulation time on supercomputers, or any other tools needed for your work have you submitted in 2019?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

24) How many proposals for observation time, simulation time on supercomputers, or any other tools needed for your work have you submitted in 2020?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

- **Conferences (face-to-face or virtual):**

25) Number of participations in international conferences and workshops in 2019 (face-to-face or virtual)?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

26) Number of participations in international conferences and workshops in 2020 (face-to-face or virtual)?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

27) Number of talks given in international conferences and workshops in 2020 (face-to-face or virtual)?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

28) Number of invitations to give a seminar in 2019 (face-to-face vs. virtual)?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

29) Number of invitations to give a seminar in 2020 (face-to-face vs. virtual)?

(0/1/2/3/4/5/6/7/8/9/More than 10/Not concerned)

30) How do you feel about your ability to focus during online events (conferences, workshops, seminars) throughout the health crisis?

(Very negative/Negative/Rather negative/No impact/Rather positive/Positive/Very positive/Not concerned)

31) How do you feel about the numbers of online events throughout the health crisis?

(Too few/Few/Sufficiently/Many/Too many/Not concerned)

- **Professional relationships:**

32) For students: How do you feel about the impact of the covid crisis on your relationships with your supervisor(s)?

(Very negative/Negative/Somewhat negative/No impact/Somewhat positive/Positive/Very positive/Not concerned)

33) For supervisors: How do you feel about the impact of the covid crisis on your relationships with your student(s)?

(Very negative/Negative/Somewhat negative/No impact/Somewhat positive/Positive/Very positive/Not concerned)

34) How do you feel about the impact of the covid crisis on your relationships with your colleagues/work team?

(Very negative/Negative/Somewhat negative/No impact/Somewhat positive/Positive/Very positive/Not concerned)

- **Post-covid:**

35) Were you doing home-office before the covid crisis?

(100% home-office/80% home-office/60% home-office/40% home-office/20% home-office/0% home-office/Not concerned)

36) How would you envision your working habits to evolve after the covid crises in terms of home-office vs. presence at the institute?

(100% home-office/80% home-office/60% home-office/40% home-office/20% home-office/0% home-office/Not concerned)

37) Would you like to adopt online conferences/seminars/meetings more often?

(Always/Often/Sometimes/Never/No opinion/Not concerned)

38) Any remarks or suggestions to improve the situation (conferences, meetings, observations, supervision, teaching, administration...)?

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