 doi:10.20944/preprints202009.0632.v1

Rebuilding the Academy: Strategies for supporting academic mothers during the COVID-19 global pandemic and beyond

*Robinson W. Fulweiler, Departments of Earth and Environment and Biology, Boston University
*Sarah W. Davies, Department of Biology Boston University
Jennifer F. Biddle, School of Marine Science and Policy, University of Delaware
Amy J. Burgin (Depts of Environmental Studies and Ecology & Evolutionary Biology, Kansas Biological Survey, University of Kansas, Lawrence, KS; burginam@ku.edu)
Emily H. G. Cooperdock (Department of Earth Sciences, University of Southern California, Los Angeles, CA, USA cooperdo@usc.edu)
Torrance C. Hanley, Marine Science Center, Northeastern University, Nahant, MA 01907, t.hanley@northeastern.edu
Carly Kenkel (Department of Biological Sciences, University of Southern California, Los Angeles, CA, 90089 USA ckenkel@usc.edu)
Amy M. Marcarelli, Department of Biological Sciences, Michigan Technological University
Catherine M. Matassa, Department of Marine Sciences, University of Connecticut, Groton, CT, USA; catherine.matassa@uconn.edu
Lory Z. Santiago-Vazquez, Department of Biology and Biotechnology, University of Houston-Clear Lake, santiago@uhcl.edu
Nikki Traylor-Knowles, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami
Maren Ziegler, Department of Animal Ecology and Systematics, Justus Liebig University Giessen, Giessen, Germany, maren.ziegler@bio.uni-giessen.de

*co-first and co-corresponding authors
rwf@bu.edu
daviessw@bu.edu

 doi:10.20944/preprints202009.0632.v1

ABSTRACT:

The issues mothers face in the academy have been discussed for decades. Routinely, new studies report significant differences between women and men at comparable career stages with respect to salary, service demands, publications, grant submissions, and overall funding rates. The COVID-19 pandemic is further exposing these inequalities as women scientists who are parenting while also engaging in a combination of academic related duties are falling further behind. COVID-19 is shaking the very foundations of our society and laying bare the many inequalities that defined our pre-COVID world. We can solve these inequities by investing strategically in creative solutions, thereby making the most of women's contributions to scientific endeavors. Here we describe strategies that would make the academy more equitable for working mothers now and into the future. Importantly, while the data are clear that mothers are being disproportionally impacted by COVID-19, many groups could benefit from these same ideas. Now is the time to act. Rather than rebuilding what we once knew, let us be the architects of a new world.

Introduction:

COVID-19 has disrupted the academic system globally and exposed long-standing inequities and vulnerabilities of underrepresented groups in the academy. Recent studies (1, 2) highlight the uneven toll the pandemic has taken on women scientists who are parenting while also engaging in multiple academic duties including teaching, research, mentoring, and service. We applaud the data-driven research documenting this phenomenon, and we welcome studies that help fill the data gap on women writ large (e.g.,(3)). That said, to women across the academy, the disproportionate toll that COVID-19 is taking on their scientific productivity as well as their mental health comes as no surprise. It is simply the manifestation of a system that was not built by or for women in general, and mothers in particular (4). The global COVID-19 pandemic will alter our society permanently. In the spirit of the well-worn adage "*never let a good crisis go to waste*," we propose using these unprecedented times as a springboard for substantive and lasting change.

First, we fully acknowledge that this global pandemic has negative, if not severe, consequences for everyone (e.g., single or coupled, with or without children, inside or outside of academia, etc.). This perspective piece is not meant to suggest that the toll of this crisis is restricted to female academics with children alone. We focus on mothers because we can speak to this personally, and because the impacts of COVID-19 within academia have been shown to be disproportionally greater on mothers. Second, we believe it is a privilege to be a mother, and this perspective piece is not meant to diminish the validity of the many womxn who are also dealing with infertility, family planning decisions, adoption, or pregnancy loss, while also navigating academia amidst a global pandemic. Finally, we recognize the diverse lived experiences of all those who identify as mothers in the academy and use maternal terminology (female, woman, and mother) with the intent of including the full spectrum of female and maternal identities. Our hope is that the solutions proposed here may be widely applicable to helping all scientists juggling personal issues as well as child- and/or elder-care while also trying to succeed in academia and beyond. Moreover, other under-supported groups such as BIPOC and LGBTQ+ academics, may require these as well as alternative strategies to ensure equity in the academy.

Ultimately, there is much work to do to foster a more inclusive environment for taking care of our families and ourselves while also pursuing research that will protect and preserve our planet and future generations. Here we provide concrete solutions to implement across multiple levels of the academic hierarchy (e.g., mentors, university administrators, publishers) that will help academic mothers in the sciences through this current crisis, while simultaneously creating long-term change for a more equitable and inclusive academy. We are confident that these strategic actions can help solve the myriad of problems mothers face (see Supplemental materials).

Potential Solutions for retaining mothers in science during and after COVID-19

 doi:10.20944/preprints202009.0632.v1

Many of our suggestions will require a monetary commitment; during times of increasing financial uncertainty, it may appear unwise to re-allocate funding in this way. However, scientists and academics have "talked" for a longtime about how to stop the "leaky pipeline" (5). Women already bear the penalty of the rigid, unchanging incentive and evaluation practices of academia. COVID-19 is only compounding structural issues that already exist. Yet, few of us are (yet) in positions of power to change this system that we did not create. Adding more women to the system is not enough. We need those in power to acknowledge these issues and commit resources to fixing them. Universities can seek alumni donations to specifically fund strategies to retain women in science. Imagine instead of having a name on a building, a donor could support initiatives for academic mothers? As examples, they could fund a daycare center or establish a fellowship to offset daycare or emergency childcare costs? Much can and should be done (Figure 1).

Before we discuss targeted strategies we highlight a universal need – everyone should be fighting for: affordable, high-quality, child care. Research has shown that when high quality daycare is provided, mothers can and do re-enter the workforce and children benefit (6–8). Thus, this type of assistance makes both ethical and economic sense. Universities should provide on-campus daycare, or subsidies for off-campus daycares, as well as funds for additional childcare support when options are limited by social distancing restrictions. Universities with childcare facilities should also prioritize reopening in safe manners including high frequencies of COVID-19 testing and sanitization practices. These resources should be made available to faculty, staff, postdocs, and graduate students, the latter of which are facing the same challenges on much lower salaries. We stress that all of us – regardless of academic position- can help push for this goal and, those in power, should be working tirelessly to make this happen.

I. Advice for mentors of women with childcare duties:

The first step to supporting mentees who become or are parents happens long before they share their exciting news or join your laboratory – **make it clear that you are wholly supportive of all personal choices and lifestyles, including family units with or without children, and that you not only value but also strive to achieve a healthy work-life teeter-totter** (9). If you are an academic mother, there is no better example for your mentees than learning from your experiences. Being a good mentor means listening to your mentees and supporting their goals, and this becomes increasingly true when your mentees become parents. Your support can be especially important when they first tell you they are expecting. Your initial reaction to this news sets the stage for how they will feel asking for what they need throughout their pregnancy, maternity leave, and return to campus. This is an emotional conversation even without the backdrop of a global pandemic. The added stress associated with COVID-19 only heightens emotions and keeping clear lines of communications open is essential. We recommend having

 doi:10.20944/preprints202009.0632.v1

weekly meetings that cover topics ranging from data analysis and manuscript revision to mental health and self-care.

I**nitiating discussions with your mentees about developing flexible timelines for both short- (e.g., lab work) and long- (e.g., graduation date) term goals in such a way that planning is viewed as positive, proactive, and supportive**. If possible, finding ways to shift time-consuming tasks, may allow graduate and postdoctoral mentees to focus their (more) limited time on tangible products critical to current and future career stages. It is also helpful to keep research moving forward. For example, outsourcing sample analysis or hiring a research technician to complete field/lab work could help meet the demands of a research project while mentees learn to juggle school and work with childcare duties. If mentoring a postdoctoral associate, PIs should work with them to apply for bridge funding.

It is also critical to **keep mentees with childcare responsibilities involved in lab interactions, departmental activities, and multi-institution collaborations.** Be conscious of not deciding whether to include/exclude mentees based on perceived availability, stress, or interest. Consider including them in collaborative projects that provide networking opportunities and the potential to learn new skills. In addition, encourage mentees to find a relevant peer group to discuss the unique challenges of navigating academia during a global pandemic while raising children. A peer group (10), can provide a safe and supportive environment for idea exchange and open discussion, as well as encouraging academic mothers to schedule time for self-care and recognize the importance of community in empowering women in the sciences (11).

Finally, **mentors need to be familiar with parental leave policies at their institutions in order to help others navigate options and make informed decisions.** In many cases, details of parental leave policies are missing critical information (12), such as where the funding comes from for paid leave. Clarifying and addressing these policy gaps ahead of time can reduce stress for mentors and mentees, and prevent mentors from trying to navigate nebulous policies, which might be particularly difficult during COVID-19 when colleges and universities are concerned about short- and long-term financial stability. If paid leave is not available, mentors should advocate for policy change and explore alternative solutions in the interim, such as leave donation.

II. Advice for University Administrators:

University administrators, including Department Chairs, Deans, and Provosts, wield enormous power over how faculty, students, and staff navigate parental duties under normal circumstances through the establishment and enforcement of policies and procedures. While it feels that every policy has been rewritten to account for COVID-19, university administrators have a responsibility to advocate and champion the types of strategies suggested below in order to

mitigate the effects of the pandemic on working mothers specifically and parents more generally. However, **administrators should not make gender neutral policies**. The pandemic is not gender neutral, thus such policies will fail to bring about greater gender equity (13, 14). Failure to address equity now will undermine decades of work and the progress made in bringing academic departments, especially STEM departments, closer to gender parity. Given the large uncertainties around the frequency and duration of COVID-19 disruptions, any changes to current policies or new policies implemented will need greater flexibility, particularly around reappointment, tenure, and promotion. The solutions described below include those first suggested by the 500 Women Scientists (15) and a letter to the University of Wisconsin Administration (16).

Departmental Chairs at research intensive institutions **should allocate any flexible funds to support research productivity of academic mothers.** Research productivity of faculty is directly correlated to the research productivity of their graduate students and postdocs. Thus, flexible funds could buy-out graduate student teaching requirements, especially if that student has childcare duties or is mentored by a woman with childcare duties. This will allow for research progress to continue, even during COVID-19. Similarly, funds could be allocated to help bridge funding gaps for postdocs with childcare duties.

Department chairs at teaching intensive institutions, **can assist by providing course releases to lessen teaching loads.** In addition, administrators can facilitate collaborations with internal or external partners that can aid in the continuation of research activities. A faculty member may be able to offer their expertise, allow access to equipment and/or facilities, and help manage a research program, potentially remotely. Faculty should be encouraged to describe the special circumstances and challenges faced while teaching in a pandemic in their annual review and/or evaluation statements.

Many universities have offered voluntary or automatic one-year blanket tenure extensions in effort to support pre-tenure faculty during the COVID-19 crisis. These extensions are offered in good faith, however previous work has shown that tenure clock extensions are viewed negatively during tenure evaluation (17) and fail to level the playing field between mothers and fathers (i.e. maternity/paternity leave; (13)). Given that academic mothers have likely already had at least one tenure clock extension, further extensions could impose additional penalties and exacerbate financial inequalities that already exist between male and female academics (18). This is particularly true when tenure evaluators don't have clear instructions for evaluating 'stoppage time' (17). One solution may be to **include only a fixed number of performance years in tenure dossiers for evaluation** (19).

Not all research programs face the same obstacles during the pandemic. Shutdowns and re-openings are highly variable between schools, states, and countries. This inequality in disruption

 doi:10.20944/preprints202009.0632.v1

will affect peer comparisons during tenure review processes and may create obstacles to retaining women, especially those who were unable to be productive during this time due to childcare responsibilities. **We recommend that all institutions incorporate a "COVID-19 Disruptions" statement in tenure and promotion files with explicit instructions for external tenure file reviewers and tenure review committees to consider inequalities generated by the pandemic**. These statements should be a required component of all tenure dossiers, even those of faculty who do not feel they've been heavily impacted by the pandemic. Each university should provide a template with clear instructions and objective criteria for limiting biases that can arise when evaluating tenure packages (17). Coupled to this, **we propose that all early career women scientists with childcare responsibilities be relieved of all departmental/university service requirements for the duration of this pandemic**. An explanation of this service release could also be appended by the Department Chair to the aforementioned supplemental COVID-19 Disruptions statement explicitly stating that the lack of service is not to be held against them during merit and promotion review and this letter would include why service was relieved. Universal instructions should also be supplied to any external evaluators so that they are aware of how the University is handling this statement and any associated tenure clock extensions. Malisch et al. 2020 provide an excellent set of questions in teaching, research, and service realms for evaluation committees to consider.

Startup expiration dates should be removed or extended to tenure receipt. Removing time constraints on startup funds allows women to make financial decisions about their labs within a time frame that works for their situation. Even better, Universities can provide support to offset 'lost start-up' in the form of RA or technician salaries, and their associated fringe expenses, that PI's continued to pay throughout lab shutdowns.

In addition to tenure clock extensions, research productivity during COVID-19 will undoubtedly negatively affect and delay the Associate to Full Professor promotion of mid-career academic mothers. The challenges post-tenure mothers face are largely ignored and it is often assumed since they are tenured they are self-sufficient even though they are tasked with additional service requirements. Even before the pandemic, women in STEM fields are underrepresented as Full Professors (20) and the road to Full Professor is often ambiguous and lacks clarity (21). Because this group of women are the most likely to assume leadership roles, and thus help change the broken academic system, we must ensure their timely promotion. **Deans and Provosts need to provide clear promotion guidelines and policies while also including specific COVID-19 policies to minimize delays to promotion. Further, strategies outlined above for early career mothers such as course releases, funding for research assistants, and lower service requirements would also benefit promotion of mid-career mothers.**

III. Advice for Scientific Societies:

 doi:10.20944/preprints202009.0632.v1

Scientific societies were previously reluctant to embrace virtual conferences because they pose significant logistical challenges and do not provide the same in person interaction as face to face conferences. Yet disability and diversity advocates have long argued that virtual meetings have the opportunity to reach larger audiences and promote inclusion (22). Virtual conferences provide more opportunities for accessibility as well as opportunities to interact with larger and more international audiences, and by removing the need for travel are more feasible for those with limited time and ability to travel, including mothers.

The sudden COVID-19 shift to virtual meetings has allowed many societies to see the benefits and work through the logistical challenges. These lessons should be leveraged to increase accessibility now and beyond this pandemic. **Society and conference planners should consider how to retain elements of virtual meetings and blend them with traditional meeting schedules when in-person conferences resume.** Options such as pre-recorded lectures and flexible start times will be especially helpful for women who are the sole or primary caretaker without outside help. **Societies should carefully consider how to balance costs to keep registration fees for virtual participants as low as possible to encourage participation by those who might be reluctant to register if their child care situation is uncertain.** Finally, now more than ever it is important to prioritize women, especially BIPOC womxn, to give plenaries and invited talks at virtual meetings, to encourage them to take the time to participate when balancing many competing demands on their personal and professional time.

Scientific societies should also continue and expand efforts to diversify their governing boards. Societies must recognize that COVID-19 poses an overwhelming challenge to working mothers and care-givers, but must not allow that to prevent recruitment into leadership positions that can be important for career advancement and promotion. Governing boards should continue to recruit diverse candidates, and mentor new governing board members on how to balance their society duties relative to other duties. Because of the instability and often shifting schedules that are associated with child care and work during COVID-19, flexibility is needed in conducting society business. As such, societies should consider using virtual and/or asynchronous communication for society business.

Some **scientific societies invest in their early career members through research awards, travel grants, or publication funds to offset costs associated with publishing in their journals.** Societies without these support mechanisms should consider implementing them to offset the effects of COVID-19 on mothers. All societies should consider ways these programs can be adapted to promote mothers and/or primary care-takers' work regardless of career stage. With the disproportionate pressure placed on mothers during this pandemic, publishing rates for women are expected to decline (1, 23). Therefore, having more opportunities, that have flexible due dates, and streamlined submissions could support mothers trying to be involved in their societies and publish their work.

 doi:10.20944/preprints202009.0632.v1

Enhancing networking opportunities for mothers could be particularly fruitful. As we have experienced through preparing this article, many mothers with little free time can join forces for productivity. Because shared experiences allow for empathy, support, and realistic expectations, especially under our current circumstances, society-supported symposia or networking activities that bring together mothers in related fields should generate new and innovative research collaborations that are supportive, satisfying, and more productive. Encouraging inclusion of a "COVID-19 impact statement" in applications for travel or research awards can help individuals highlight the ways that the shutdown has impacted their research and home situations to ensure that funds are distributed to meet the greatest needs (24). Finally, considering flexibility in travel or research awards to be used towards child care costs could offset the time and financial burden for mothers as they contribute to society activities and scholarship.

IV. Advice for Publishers:

In an academic culture of 'publish or perish' one main metric of scientific evaluation is research output in the form of peer-reviewed papers. Within the first few weeks of this pandemic, manuscript submissions by female researchers to preprint servers across disciplines dropped significantly or increased less than their male colleagues (23, 25, 26). This trend was also apparent for women-led medical studies related to the pandemic itself (27, 28). Due to the time-lag of the publishing process from preprint to peer-reviewed articles, we expect that these disparities will further increase throughout the course and the aftermath of the pandemic. Publishers and editors are at the center of the publishing machinery and have an opportunity to counterbalance these long-term detrimental effects on equitable science. Measures already being considered include **expediting submissions from self-identified women, by prioritizing them during the peer-review process** (29). During the COVID-19 pandemic many journals have extended their deadlines to return reviews and to perform revisions - particularly decreasing the pressure on working mothers. We advocate to adopt this practice more broadly across journals and to continue offering extended deadlines for the foreseeable future.

Open access (OA) publications attract a broader audience and get cited more frequently (30), however open access fees are high. **OA Fee waivers could be extended to a certain proportion of manuscripts led by mothers without childcare during this pandemic**. Similarly, manuscript images on journal covers help to highlight research and efforts could be made to make studies by mothers more visible, thereby allocating journal cover space in a more equitable manner. Men dominate editorial boards (24, 31) and they are still twice as likely to be invited to submit papers to journals that consequently have higher acceptance rates (32). There is simply no excuse for this – **invite and incentivize women to join editorial boards, recruit them to apply for Editor-in-Chief positions. Editors can amplify female voices by inviting them to write**

 doi:10.20944/preprints202009.0632.v1

review or preview articles, as these papers get higher citations rates and often indicate that the author is well-established in the field (24, 29)**.**

V. Advice for Funding Agencies:

Analogous to the advice for Colleges and Universities, nuanced approaches will be needed to address the variable impacts of COVID-19 on the community, and on academic mothers in particular who, even before the pandemic, were submitting fewer grants than their male colleagues (33). Facilitating no-cost-extensions is a first step, but it is likely that multi-year extensions will be needed. **We recommend that agencies consider what steps can be taken to reduce the paperwork burden associated with sequential applications, which are likely to disproportionately be needed by PIs with additional care-giving roles.** A streamlined mechanism for proposing scope of work revisions and re-budgeting requests would allow academic mothers to focus efforts on progressing research. This will be most essential for in-progress awards where salary support for students and postdocs has continued while their ability to complete project objectives has been hampered, creating a budget imbalance. **Funding agencies could consider making supplemental awards during extensions to allow for additional salary support for grant-funded project personnel to facilitate completion of the original scope of work when research is able to resume safely**. If additional funds are available, agencies could also consider developing short-term bridge funding awards to support academic mothers at all career stages as mothers are more likely than fathers to leave full-time STEM positions due to increasing childcare needs (34).

Finally, agencies should also consider how impacts to productivity during this period will reflect on future funding applications. For example, the National Science Foundation requires a succinct summary of results from prior funding support. **Incorporation of a COVID Disruptions statement could facilitate a more objective assessment of publications and products**.

Conclusions:

This perspective piece was inspired when yet another study was published on how working scientist mothers are disproportionately impacted by consequences of the COVID-19 pandemic, and we found ourselves confronted with the realization that the academy was now publishing data-driven science showcasing our lived experiences as academic mothers. These studies are important because they provide data that can be leveraged to raise awareness of the issues we experience in our careers, both in the past and now during this exceptionally challenging time. However, data do not solve problems. We need actionable solutions. Here we described a series of strategies across spheres of influence that can help reduce the burden of this global pandemic on mothers in science. As working mothers, we cannot solve this problem or implement these solutions alone. We implore our universities, societies, and scientific leaders to carefully

 doi:10.20944/preprints202009.0632.v1

consider where and when they could leverage their power to implement the solutions we have presented here. Importantly, we urge leaders not to forgo action simply because a solution did not work before. Such a failure could be due to "false fails" – i.e., the strategy was not implemented correctly, for long enough, at the right time, etc. (Table 1). Ultimately, science and our world will benefit when there is equity for women and mothers.

Acknowledgements:
We thank the following individuals for reviewing earlier versions of this manuscript: Pete Buston, Kim McCall, and Richard Primack (Boston University) and Pete Girguis (Harvard University). We thank our families for providing motivation and support. We thank all womxn academics who helped forge the paths we now tread.

References:

1. K. R. Myers, *et al.*, Unequal effects of the COVID-19 pandemic on scientists. *Nat. Hum. Behav.* (2020) https:/doi.org/10.1038/s41562-020-0921-y.
2. F. Staniscuaski, *et al.*, Gender, race and parenthood impact academic productivity during the COVID-19 pandemic: from survey to action. *bioRxiv* (2020) https:/doi.org/10.1101/2020.07.04.187583.
3. C. Criado-Perez, "The Default Male" in *Invisible Women: Data Bias in a World Designed for Men*, (2019).
4. M. Goulden, M. A. Mason, K. Frasch, Keeping Women in the Science Pipeline. *Ann. Am. Acad. Pol. Soc. Sci.* (2011) https:/doi.org/10.1177/0002716211416925.
5. K. E. Grogan, How the entire scientific community can confront gender bias in the workplace. *Nat. Ecol. Evol.* (2019) https:/doi.org/10.1038/s41559-018-0747-4.
6. V. J. Hotz, M. Wiswall, Child Care and Child Care Policy: Existing Policies, Their Effects, and Reforms. *Ann. Am. Acad. Pol. Soc. Sci.* (2019) https:/doi.org/10.1177/0002716219884078.
7. T. W. Morrissey, Child care and parent labor force participation: a review of the research literature. *Rev. Econ. Househ.* (2017) https:/doi.org/10.1007/s11150-016-9331-3.
8. A. Grönlund, I. Öun, Minding the Care Gap: Daycare Usage and the Negotiation of Work, Family and Gender Among Swedish Parents. *Soc. Indic. Res.* (2020) https:/doi.org/10.1007/s11205-020-02366-z.
9. A. Sponberg, Riding the Work–Life Teeter-Totter. *Limnol. Oceanogr. Bull.* (2019) https:/doi.org/10.1002/lob.10292.
10. H. Shkolnik, E.L., Surcel, A., Shahar, A., Jang-Condell, In Person: Career GPS. *Science (80-.).* (2012).
11. M. C. Horner-Devine, J. W. Yen, P. N. Mody-Pan, C. Margherio, S. Forde, Beyond traditional scientific training: The importance of community and empowerment for women in ecology and evolutionary biology. *Front. Ecol. Evol.* (2016) https:/doi.org/10.3389/fevo.2016.00119.
12. K. Boswell, M. McEacharn, K. Chauhan, S. Siereveld, Tenure clock policy transparency for biological clock (family friendly) events. *Adm. Issues J. Educ. Pract. Res.* (2019) https:/doi.org/10.5929/9.2.4.
13. H. Antecol, K. Bedard, J. Stearns, Equal but inequitable: Who benefits from gender-neutral tenure clock stopping policies? *Am. Econ. Rev.* (2018) https:/doi.org/10.1257/aer.20160613.
14. J. L. Malisch, *et al.*, Opinion: In the wake of COVID-19, academia needs new solutions to ensure gender equity. *Proc. Natl. Acad. Sci. U. S. A.* (2020) https:/doi.org/10.1073/pnas.2010636117.
15. 500 Women Scientists, Recommendations to Minimize Career Penalties for Parents in STEM Fields During the COVID-19 Pandemic. 1–7.
16. S. . Rytilahti, J. Schuttlefield Christus, Women's & Gender Studies Consortium Letter to UW Administrators (2020).
17. C. F. Manchester, L. M. Leslie, A. Kramer, Is the clock still ticking? an evaluation of the consequences of stopping the tenure clock. *Ind. Labor Relations Rev.* (2013) https:/doi.org/10.1177/001979391306600101.
18. C. Doucet, M. R. Smith, C. Durand, Pay Structure, Female Representation and the Gender Pay Gap among University Professors. *Relations Ind.* (2012)

https:/doi.org/10.7202/1008195ar.

19. M. Htun, Tenure and promotion after the pandemic. *Science (80-.).* (2020) https:/doi.org/10.1126/science.abc7469.
20. C. Demetry, E. L. Lingo, Transforming the associate-to-full promotion system: Wrestling with strategic ambiguity and gender equity in *ASEE Annual Conference and Exposition, Conference Proceedings*, (2019).
21. J. Hart, Dissecting a gendered organization: Implications for career trajectories for mid-career faculty women in STEM. *J. Higher Educ.* (2016) https:/doi.org/10.1353/jhe.2016.0024.
22. G. Viglione, A year without conferences? How the coronavirus pandemic could change research. *Nature* (2020) https:/doi.org/10.1038/d41586-020-00786-y.
23. E. Muric, G., Lerman, K. and Ferrara, COVID-19 amplifies gender disparities in research. *arXiv Prepr. arXiv2006.06142.* (2020).
24. V. Gewin, The career cost of COVID-19 to female researchers, and how science should respond. *Nature* (2020) https:/doi.org/10.1038/d41586-020-02183-x.
25. M. Frederickson, COVID-19's gendered impact on academic productivity.
26. P. Vincent-Lamarre, C. R. Sugimoto, V. Larivière, The decline of women's research production during the coronavirus pandemic. *Nat. Index* (2020).
27. J. P. Andersen, M. W. Nielsen, N. L. Simone, R. E. Lewiss, R. Jagsi, COVID-19 medical papers have fewer women first authors than expected. *Elife* (2020) https:/doi.org/10.7554/eLife.58807.
28. A. C. Pinho-Gomes, *et al.*, Where are the women? Gender inequalities in COVID-19 research authorship. *BMJ Glob. Heal.* (2020) https:/doi.org/10.1136/bmjgh-2020-002922.
29. D. Conley, J. Stadmark, Gender matters: A call to commission more women writers. *Nature* (2012) https:/doi.org/10.1038/488590a.
30. G. Eysenbach, Citation advantage of open access articles. *PLoS Biol.* (2006) https:/doi.org/10.1371/journal.pbio.0040157.
31. C. M. Topaz, S. Sen, Gender representation on journal editorial boards in the mathematical sciences. *PLoS One* (2016) https:/doi.org/10.1371/journal.pone.0161357.
32. L. Holman, D. Stuart-Fox, C. E. Hauser, The gender gap in science: How long until women are equally represented? *PLoS Biol.* (2018) https:/doi.org/10.1371/journal.pbio.2004956.
33. L. J. RissleR, K. L. Hale, N. R. Joffe, N. M. Caruso, Gender Differences in Grant Submissions across Science and Engineering Fields at the NSF. *Bioscience* (2020) https:/doi.org/10.1093/biosci/biaa072.
34. E. A. Cech, M. Blair-Loy, The changing career trajectories of new parents in STEM. *Proc. Natl. Acad. Sci. U. S. A.* (2019) https:/doi.org/10.1073/pnas.1810862116.

 doi:10.20944/preprints202009.0632.v1

Table 1: Solutions to false fails. Identified problems, common false fails and proposed solutions.

Problem	False Fail	Proposed Solution
Need better access and cheaper childcare	It's just too expensive to provide daycare	University provides daycare. Subsidize daycare on a sliding scale - with free daycare for graduate students, discounted daycare for postdocs, assistant professors.
Teaching release for women scientists during Covid	Who would do the teaching?	Postdoctoral teaching fellowships
Decreased attendance at conferences	Virtual conferences are not as fun, we miss the one-on-one interactions	Provide conferences in multiple modalities
Women under-represented on Editorial Boards	Mid-career women turn down invitations to be editors due to time constraints, but men accept invitations; under-representation of women too hard to change.	Talk with the women you invite to help brainstorm how they could participate in an editorial board. For example, could they decrease their departmental/university service level? Is it possible for them to handle less manuscripts? Are there incentives that could make picking up this new service more appealing (e.g., one free open access publication in the journal per year)
These solutions require money	Universities do not have money to implement these solutions	Universities are able to raise money for new sports arenas, buildings, and invidivual labs/projects. Why not for keeping women in science?

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 26 September 2020 doi:10.20944/preprints202009.0632.v1

Figure 1

Figure 1. Overview of the proposed strategies to help support mothers in Biological and Environmental Sciences through COVID-19 and beyond. These same strategies may also help fathers and elder-care givers. Other unsupported groups may benefit from these strategies, and may also need additional strategies. (*Figure is a rough draft*)

Supplemental Text

Overview of Motivation to write this piece

Investigators with young families, and especially female principal investigators (PIs), are experiencing negative impacts as a result of work from home policies coupled with ongoing childcare and school opening challenges and resultant homeschooling. For example, childcare is sparse or unavailable due to mandated physical distancing restrictions that have led to significant reductions in capacity at some facilities, and permanent closures of others. This has forced parents to keep children at home with limited/no back-up care options. Even as schools re-open, many schools are offering hybrid instruction, which limits uninterrupted windows for academic work. Moreover, many families cannot risk sending their children back to daycare or school for fear of infection and face the prospect of having their children schooled from home, via virtual instruction or traditional home-schooling. Parents, and in particular women, are tasked with facilitating their children's learning and enrichment coupled with the expectation to maintain research productivity and teaching excellence, often without outside assistance. Notably, research suggests that even in dual career households, mothers often perform a greater proportion of child care and household duties when compared to fathers (1, 2) and, while new parents are more likely to leave full-time STEM jobs than their childless peers, new mothers are twice as likely to leave STEM as new fathers (3).

The current childcare and schooling situation is especially hard on pre-tenure mothers who struggle to bolster their scientific productivity while also remaining engaged with their family. That said, mothers at all career levels with children or elders at home may be disproportionately affected by policies associated with COVID-19. We fear an increase in tenure denials related to COVID-19, as well as a decrease in promotions to Full Professor, thereby continuing to limit the number of women advancing into leadership positions within the academic pipeline (4–6). Of course, delays in career advancement also apply to those not on the tenure track and may be especially difficult for academic mothers in adjunct or lecturer positions, which are more likely to be in jeopardy due to the financial ramifications of COVID-19.

Consequences of the COVID-19 pandemic on research for academic mothers

Although the general consequences of COVID-19 on academia are substantial and have been discussed in detail (e.g.,(7)), BES research programs may be especially impacted due to an emphasis on long-term datasets, fieldwork, and large-scale laboratory and field experiments that require teamwork. Of course, the impact of the COVID-19 pandemic on research productivity will be largely dependent on the type of research conducted in each lab and each investigator's personal responsibilities. The effects of lab shutdowns are especially difficult for empirical or experimentally-focused researchers. These impacts are even more severe for those labs conducting research that requires fieldwork, which has become largely intractable during the pandemic due to loss of access to field sites, cancelation and/or bans of domestic and international travel, and limitations on the number of field researchers due to physical distancing requirements. The long-term consequences of delayed/canceled field seasons are more likely to negatively influence mothers due to childcare responsibilities. As travel and field sites reopen, mothers without access to childcare will need to prioritize childcare responsibilities and will remain unable to travel, ultimately extending the consequences of COVID-19. Even as childcare facilities reopen in their

region, it may be too risky to dedicate time to planning and conducting field work - especially at remote locations - due to fears of future campus or field site shutdowns, which would again render fieldwork impossible and potentially make community and/or family members sick.

Junior members of the research community, which are more likely to be women (8), will be hit hardest because projects and graduate students are more likely to be in early phases. As a consequence, junior investigators are often left focusing on literature reviews or completing legacy datasets from their previous positions. In addition, because many women choose to wait to start their family until after they find a permanent academic position (5), these consequences are again more likely to have a larger impact on academic mothers. Lastly, physical distancing restrictions have limited the number of researchers in labs and will therefore impose greater limitations on PIs with small lab spaces, which are again most likely to be female early-career PIs (9).

Publications are the currency in academia; however, the publication process itself has experienced upheaval due to COVID-19 (10–13). In general, the process has slowed significantly, from obtaining reviews to receiving proofs, which decreases publication rates and has implications for resulting citation rates. In addition, editors are reporting surges in manuscript submission that are disproportionately led by male authors (10, 14), and this influx in submissions is likely to lead to increased competition for already limited space in journals. While many academic mothers have been able to perform some level of analysis and manuscript drafting during the pandemic, the pace of publication and subsequent citation rates will inevitably experience greater lag times. This will only be compounded in fields that require multiple year data sets or extensive fieldwork. Child rearing during this global pandemic has left academic mothers with even smaller units of time, which makes deep intellectual thought and writing, which are required for both publications and grants, next to impossible. These sorts of hurdles have specifically left mothers publishing significantly less than their colleagues without children (15).

The abrupt transition to online teaching in spring 2020 presented a new challenge for all academics. These challenges were especially felt by women caring for young children and/or leading the at-home learning requirements for children. Now, many institutions are moving to a hybrid model of teaching for fall, essentially doubling the course preparation required at a time when many women remain child caregivers at home. Similarly, women graduate students with childcare responsibilities and who serve as teaching assistants (common practice in the BES field) now have to spend more time re-developing course materials to complement online learning needs, which detracts from time spent on their dissertations.

Grant deadlines have not been significantly altered and we anticipate significant changes may be made to federal funding rates and priorities as a result of the pandemic and associated economic fallout. It seems inevitable that institutional internal grants will be slashed with impending budget cuts, and likely that state and federal grant agencies will be restricting funds in order to deal with financial repercussions of COVID-19. While these cuts will affect all academics, academic mothers who are also balancing childcare responsibilities will not have the bandwidth to submit grants in hopes of getting funded before these looming COVID-19 cuts are made. These issues are compounded by the fact that women at all career stages were already applying for grants at lower rates (8). Because the grant review cycle takes approximately 6 months, missing deadlines now means less future funding. This decrease in grant

 doi:10.20944/preprints202009.0632.v1

565 applications by mothers will perpetuate the impacts of the pandemic for years to come. For some, it may
566 result in insufficient funding to continue in science altogether.
567
568 Travel restrictions and the associated loss of networking opportunities has implications for initiating
569 collaborations, demonstrating research productivity, and connecting with potential external review
570 evaluators. A massive number of in-person networking opportunities have evaporated through cancelled
571 regional, national, and international meetings and seminar invitations, and reduced numbers of seminar
572 speakers visiting campuses. By necessity, many of these opportunities have moved to an online format.
573 Ironically, many organizations are touting this as an opportunity for increased inclusion, under the
574 auspices that online events can be attended by any and all who are interested. That presumption is not
575 true, as women at home who have childcare obligations are hindered in participating because they may
576 not have the physical space or time to do participate in professional activities. Further, many women feel
577 that they also do not have the mental and emotional space to prepare and present a research seminar under
578 the current circumstances. Declining these opportunities decidedly impacts their careers as networking is
579 a principle means of generating career opportunities such as new collaborations and job offers. Plus, the
580 connections made during these visits often result in offers of reviewers of promotion and tenure packets,
581 thereby potentially limiting the dissemination and recognition of early career scientists. Finally, annual
582 merit review as well as tenure and promotion packages keep track of these seminars as a way to assess
583 how faculty are regarded in their field.
584
585 Lastly, the long-term effects on the productivity and mental health of graduate student mothers remain
586 unclear. While substantial focus is understandably being given to late-career Ph.D. students and
587 postdoctoral researchers facing immediate funding and job market challenges, the younger cohorts must
588 also be considered. For some postdocs and graduate students, child rearing has now been compounded on
589 top of these already leaky stages in the academic pipeline (16) that require intense levels of productivity.
590 Clearly, the COVID-19 pandemic has the potential to make an already leaky pipeline burst, especially
591 when it comes to academic mothers. People in positions of power now have the opportunity and
592 responsibility to ensure that this does not occur.

References

1. L. Craig, Does father care mean fathers share? A comparison of how mothers and fathers in intact families spend time with children. *Gend. Soc.* **20**, 259–281 (2006).
2. L. Sallee, M., Ward, K. and Wolf-Wendel, Can Anyone Have it All? Gendered Views on Parenting and Academic Careers. *Innov. High. Educ.* **41**, 187–202 (2016).
3. E. A. Cech, M. Blair-Loy, The changing career trajectories of new parents in STEM. *Proc. Natl. Acad. Sci. U. S. A.* (2019) https:/doi.org/10.1073/pnas.1810862116.
4. M. Bonawitz, N. Andel, The Glass Ceiling Is Made of Concrete: The Barriers to Promotion and Tenure of Women in American Academia. *Forum on Public Policy Online* (2009).
5. M. Goulden, M. A. Mason, K. Frasch, Keeping Women in the Science Pipeline. *Ann. Am. Acad. Pol. Soc. Sci.* (2011) https:/doi.org/10.1177/0002716211416925.
6. F. Staniscuaski, *et al.*, Impact of COVID-19 on academic mothers. *Science (80-.).* (2020) https:/doi.org/10.1126/science.abc2740.
7. J. L. Malisch, *et al.*, Opinion: In the wake of COVID-19, academia needs new solutions to ensure gender equity. *Proc. Natl. Acad. Sci. U. S. A.* (2020) https:/doi.org/10.1073/pnas.2010636117.
8. L. J. Rissle R., K. L. Hale, N. R. Joffe, N. M. Caruso, Gender Differences in Grant Submissions across Science and Engineering Fields at the NSF. *Bioscience* (2020).
9. S. E. Acton, A. J. Bell, C. P. Toseland, A. Twelvetrees, A survey of new PIs in the UK. *Elife* (2019) https:/doi.org/10.7554/eLife.46827.
10. C. Flaherty, No Room of One's Own. *Insid. High. Ed* (2020).
11. J. P. Andersen, M. W. Nielsen, N. L. Simone, R. E. Lewiss, R. Jagsi, COVID-19 medical papers have fewer women first authors than expected. *Elife* (2020) https:/doi.org/10.7554/eLife.58807.
12. E. Muric, G., Lerman, K. and Ferrara, COVID-19 amplifies gender disparities in research. *arXiv Prepr. arXiv2006.06142.* (2020).
13. K. R. Myers, *et al.*, Unequal effects of the COVID-19 pandemic on scientists. *Nat. Hum. Behav.* (2020) https:/doi.org/10.1038/s41562-020-0921-y.
14. M. Frederickson, COVID-19's gendered impact on academic productivity.
15. L. Edwards, S.M. & Snyder, Yes, balancing work and parenting is impossible. Here's the data. *Washington Post* (2020).
16. L. Lee, just the facts ma'am: the gender gap in academia, from the classroom to the bank. *FASEB J.* (2015).