

A Year Into the Pandemic: An Update on Women in Science, Technology, Engineering, Math, and Medicine (STEMM)

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Abstract

The coronavirus pandemic revealed long-standing, unaddressed fissures in our systems, including dramatic gender inequities in science, technology, engineering, mathematics and medicine (STEMM) fields. Women have disproportionately carried the burden of child care and other caregiving responsibilities during the pandemic, and there are strong indications that the pandemic will likely exacerbate pre-existing disparities in the pipeline of women in STEMM and in leadership positions. Based on a literature review, our own experiences and the experiences of our colleagues, we review promising strategies that have been implemented by funding bodies, journals, professional societies, and colleges/universities as well as additional strategies that might be helpful for these entities to implement in order to move forward with policies in place that address gender inequities and rebuild our institutional systems better. At this moment in time, institutions should collect data on metrics such as recruitment, retention, tenure/promotion, funding, professional society membership, awards/honors, and scientific publishing. These data will be essential in determining the impact of policies on women in STEMM to ensure they are having the intended effect as well as what future actions might be necessary in an iterative process.

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As we had feared (1), the COVID-19 pandemic revealed long-standing, unaddressed fissures in our systems, including dramatic gender inequities in science, technology, engineering, mathematics and medicine (STEMM) fields. Research indicates that women in STEMM managed the majority of caregiving during the pandemic (2, 3), with women in STEMM being more likely to report considering leaving their institution, decreasing their hours to part-time, or turning down leadership opportunities in 2020-2021 compared to men (4). Concurrent with the drop in productivity and work hours (2, 3), there has been a precipitous drop in the submission of manuscripts by women (2, 3). Thus, the impact of the COVID-19 pandemic will likely exacerbate pre-existing disparities in the pipeline of women in STEMM, as well as women in leadership positions (5, 6). In addition, while caregiving for children and other family members often dominate the conversation about gender inequities and have been exacerbated during the pandemic, many gender disparities in STEMM fields are unrelated to caregiving, and instead reflect salary discrepancies (7), disproportionate service burdens (8), and disparate expectations of mentoring, nurturing, and mental health support from women in STEMM (9). These inequities may also have been exacerbated during the pandemic, especially for women in clinical fields directly impacted by the care of patients affected by SARS-CoV-2.

As we contemplate life in the COVID-19 era over one year after social distancing measures were instituted, we believe that continuing the journey to dismantle gender inequities in STEMM will require intentional identification of promising strategies that have been implemented, as well as additional strategies that might be worth exploring. As we do so, it will be important to consider not making all gender-neutral policies, when we know that women in STEMM have been differentially impacted by the pandemic (2, 3). Additionally,

policies implemented in response to the pandemic must be evaluated to determine the impact on women in STEMM to ensure they are having the intended effect. This is especially true given existing data on the widening of gender disparities that have occurred in academia after the implementation of gender-neutral policies in the past, such as tenure clock extension policies (10).

The goal of this paper is to review promising policies, programs, and procedures that have been recently implemented in STEMM, many in response to the COVID-19 pandemic with a critical eye towards potential effectiveness. We subsequently propose further strategies which have not yet been implemented. In both sections, we enumerate strategies by the institution that might consider them (i.e., funding bodies, journals, professional societies, or academic institutions/practices). The strategies we review were identified through a combination of literature review (including peer reviewed manuscripts; websites of funding bodies, journals, professional societies, and universities/colleges; and blogs), informally soliciting ideas from national and international colleagues, and from the authors' own viewpoints and experiences within science, medicine and academia.

Promising Programs That Have Been Recently Implemented

The following programs have been implemented at academic institutions across the United States and represent promising ideas that should be evaluated to determine whether they have the intended effect of reducing gender disparities in STEMM.

Funding Bodies

- **Tracking the impact of gender on funding:** The National Institutes of Health (NIH) quickly started tracking data on funding during the COVID-19 pandemic by gender (11). While these data have not indicated marked changes in grant submissions by gender due to the pandemic, it will be important to continue to follow the data on submissions as well as funding decisions, in order to determine whether there have been longer-term effects on women. Should long-term effects be detected, programs to address these effects should be implemented (e.g., prioritization of funding for women).
- **Implementing early career caregiver supplemental funding to facilitate success with research grants:** Just prior to the COVID-19 pandemic in January 2020, the NIH announced new administrative supplements for career development (12) or first-time research project grant awardees (13) to sustain research through additional research personnel or other costs during “critical life events” (e.g., childbirth, adoption, other caregiving). In addition, the NIH announced in March 2021 that graduate students and postdoctoral fellows funded on National Research Service Awards are able to request \$2500 in additional funds per year to defray child care costs and thus more fully participate in their research (14). Given that awards of these types typically occur in the prime childbearing years, these supplemental funds may help prevent the loss of women from the STEMM pipeline, especially for women in medicine who were asked to expand their clinical duties in response to the pandemic at the expense of time for their research. Tracking the use of these supplemental funds will provide essential data on the impact on retention of women in STEMM.

Journals

- **Prioritizing reviews of manuscripts by women:** Since gender disparities in manuscript submissions during the COVID-19 pandemic are well-documented (2, 3), journals should consider how they can help to address these disparities. The *International Journal of Urban and Regional Research*, for example, has committed to prioritizing women and early-career researchers by putting their papers at the front of the review queue (15). Other journals should test policies to address gender disparities in publications. Journals should also examine trends in manuscript submission to determine when and if women's submissions have recovered.
- **Tracking the representation of authors and reviewers to improve diversity of perspectives:** To begin to address existing disparities (16) as well as facilitate examining representation across genders among authors and reviewers, journals could collect demographic data to avoid relying on incomplete name-based inferences (17). The *Lancet Group* journals recently instituted this policy (18). Once these data are available, journal leadership should publicize the summary data, determine whether reviewers or editors are exhibiting gender bias in their evaluation of manuscripts, and provide corrective actions, as appropriate.
- **Prioritizing women on editorial boards:** The *Lancet Group* has also pledged to ensure that their editorial boards are at least 50% women, which will likely diversify not only the perspectives represented in the editorial boards but the literature published (18). Given the data indicate the lack of gender diversity on editorial boards across areas of STEM (19, 20), continued efforts such as these will be crucial.

Professional Societies

- **Tracking and increasing gender diversity in membership and leadership:** To facilitate appropriate representation (21, 22), professional societies should track and report gender composition of members and leadership, similar to the Obesity Society's recent effort to conduct a diversity assessment of the membership in order to inform future efforts (23). Data such as these should then spur recruitment, mentorship, and retention efforts within professional societies.
- **Establishing caregiver travel grants for annual meetings:** Primary caregivers, who are more frequently women (24, 25), often face barriers to participate in professional development opportunities (26, 27), including attending annual meetings for their professional societies. Like the American Society of Nutrition (28), societies could establish and maintain grants for covering caregiving expenses during annual meeting attendance either on-site or at home, to see whether they facilitate professional development and networking opportunities. Additionally, it may be beneficial to expand caregiver travel grant programs to facilitate women's participation in key professional development opportunities such as the National Institutes of Health's Early Career Reviewer Program, a strategy recently instituted by the University of Chicago (29) and Brown University (30).
- **Pledging to eliminate "manels":** Many organizations, including the National Institutes of Health (31) and conferences organized by *Nature* (32), have taken the pledge since 2019, to evaluate panels for gender diversity and if necessary, modify invitations before finalizing the speaker line-up. Organizations should be held accountable for these pledges and report how these pledges have changed the composition of panels over time.

Colleges, Universities, and Medical Practices

- **Provision of funding to remove obstacles to productivity:** To facilitate the recovery from the productivity losses from the COVID-19 pandemic, it may be beneficial for colleges/universities and medical practices to develop small grants, like the program at Lehigh University (33), for removing obstacles to productivity (e.g., house cleaning, prepared meals, child or elder care), in order to allow those researchers who were most impacted to re-start their research programs.
- **Provision of pandemic-related course releases for research recovery:** It may also be helpful to implement reduced loads or no teaching responsibilities for a semester for early career faculty who have been most impacted by the pandemic due to caregiving or clinical responsibilities, similar to the program that Stanford University recently announced (34).
- **Extending expiration dates on start-up funds:** In particular for early career faculty, institutions should consider extending expiration dates on start-up funds, in a similar fashion to the recent announcement from Utah State University (35). A policy such as this may be particularly important for women since they tend to receive smaller amounts of start-up funding than men (36).
- **Recognition of additional measures of professional success:** As was recently implemented at Indiana University-Purdue University Indianapolis (37), institutions should add new measures of academic success to promotion and tenure metrics, including work dedicated to diversity, equity and inclusion efforts, scientific communication, mentorship, building community partnerships, and translating research into practice or policy. Since most individuals who work to advance diversity, equity, and inclusion are women or from other

traditionally underrepresented and marginalized groups in academia (38, 39), institutions should recognize and reward a sustained focus on this work, in similar manner as the current focus on success in publications and grant-funding. Similar measures of professional success could also be applied to clinical settings and be incorporated into metrics for leadership positions, compensation and promotion.

- **Testing the effectiveness of COVID-19 impact statements in tenure and promotion**

processes: Clear guidelines for reporting the impact of the COVID-19 pandemic for tenure and promotion committees are starting to be established, like at University of Massachusetts-Amherst (40). It may be helpful for institutions to require that all tenure and promotion candidates prepare a COVID-19 impact statement so that the degree of impact (or lack thereof) can be systematically assessed (41). Institutions should then study how these statements are interpreted by tenure and promotion committees, particularly in light of documented gender bias in the outcomes of other similar documents (42, 43). It will be particularly crucial to examine the impact of multiple tenure clock extensions (i.e., a combination of parental and pandemic-related extensions) for early career academic women, as this group is known to take the majority of the non-pandemic-related tenure clock extensions (e.g., extensions for parental leave) (44). Furthermore, since women are underrepresented at the full professor level (5, 45), the focus must not be solely on early career faculty and tenure decisions, but also on the promotion of mid-career women. Overall, all of these goals will require the development of institutional systems for tracking the tenure and promotion processes by gender and also for sharing these data with the institutional community.

- **Bolstering strategies for the recruitment of women to STEMM positions:** Recent research indicates that many U.S. medical schools have no programs supporting gender equity in recruitment, retention, and promotion of medical faculty (46). To address this glaring omission, it may be beneficial for hiring committees within any institution or clinical practice to establish requirements for candidate pool composition, especially as there is some research indicating that there should be at least 2 women in a candidate pool (47, 48)) to ensure diverse hires. This initiative would require institutions to track and report the demographic characteristics of candidate pools and could begin to address persistent disparities in women in leadership positions (49, 50). There is promising research that the use of implicit bias trainings (48, 51), including interactive theater workshops focused on demonstrating how biases emerge in the search process and developing strategies to overcome these biases (52), may be helpful. Finally, it may be necessary to incentivize gender equity initiatives in recruitment, retention, and promotion. For instance, the Athena SWAN initiative in the United Kingdom requires institutions to demonstrate a tangible commitment to gender equity principles to be eligible for government funding (53), and these institutions have been successful at instituting some policies that are not gender-neutral (54).

In the conclusion to this section, we do want note that, despite the innovation in these programs listed above, many are gender-neutral, and it is unclear whether they are going to have their intended effect of reducing gender disparities in STEMM (or potentially have harmful effects). Thus, it will be important to evaluate these programs, to identify which are effective in

closing long-standing gender gaps as well as which are helpful in addressing acute pandemic-related issues, in order to inform broader implementation.

Strategies to Address Gender Disparities Which Have Not Been Broadly Implemented and Merit Evaluation

Funding bodies

- **Broaden the use of strategies for eliminating bias in the funding review process:** Given the demonstrated gender bias in the peer review system for funding (55, 56) and the impact of research funding on career longevity (57, 58), strategies must be tested for how best to mitigate these biases. One possibility would be to test the impact of blinding the reviewer in the first round of review to the investigator (including the investigators' names and institution), similar to the new protocol for evaluating the NIH Director's Transformative Research Award Applications (59).
- **Establish funding for testing diversity, equity and inclusion strategies:** As previously mentioned, most individuals who work to advance diversity, equity, and inclusion are women or from other traditionally marginalized groups (38, 39); however, there are limited funding opportunities focused on these topics. In addition to large national programs (e.g., ADVANCE (60)) focused on these important topics, there should be smaller local and national awards to support, evaluate and amplify the impact of this work, in order to inform policies at other institutions.

Journals

- **Eliminate unprofessional or biased reviewer comments on manuscripts:** Unprofessional reviewer comments are more commonly experienced by women than men (61). Ideally, journals would establish policies to have the editor remove the inappropriate comments prior to passing the reviews along to the authors and provide guidance to the reviewer about what is appropriate to include in manuscript reviews (62). In addition, there should be a clear path for authors to provide feedback to the editor regarding inappropriate reviewer comments, that does not jeopardize the manuscript status.
- **Increase awareness about gendered citation practices:** Authors who are women are less likely to be cited (63), particularly when women are a small minority within the research field (64). This citation gap may be compounded by the greater degree of self-citation by men compared to women (65, 66). This lack of citation of women's research is particularly consequential with regard to tenure and promotion, which often requires that the scholar establish a national/international reputation and citation metrics such as the h-index is one common way to evaluate this standing. Journals could test strategies for overcoming this disparity, such as using tools to provide authors and reviewers feedback on the gender balance of referenced materials and the number of self-citations in comparison to journal norms. This strategy could increase awareness about citation practices as well as limit reviewers' power in suggesting their own articles within the peer review process (67).

Professional Societies

- **Track and increase diversity of professional society awards:** Women are less likely to receive awards by professional societies, particularly research-related awards (68, 69), compared to men. Given the apparent relationship between the gender of the award committee chair and the awardee's gender (69), professional societies should prioritize gender parity in the leadership of these committees and track the gender of the awardees to demonstrate progress.

Colleges, Universities, and Medical Practices

- **Implement specific funding for pandemic research recovery:** In order to help researchers who have been most impacted by the pandemic back on their feet after the pandemic, it may be helpful to establish funding opportunities specifically focused on making up for lost start-up funds that maintained students and staff during the pandemic or lower productivity due to caregiving or clinical responsibilities.
- **Eliminate gender bias in evaluations:** Evaluations of faculty (70), medical students (71), and residents (72) are known to be biased against women. The validity of these evaluations may be particularly questionable for courses or clinical care that occurred during the pandemic (73). It is long overdue for institutions to address this bias, which negatively impacts the recruitment, retention and promotion of women in STEMM. Brief interventions designed to raise awareness of gender bias in evaluations have been proposed and should be further tested (74, 75).

- **Increase visiting speaker diversity:** It will be necessary to track and reward progress toward closing the gender gap for visiting speakers, given the known gender disparity in invitations for prominent speaking opportunities (76, 77). The hosts of these speakers should also ensure parity in the honoraria and travel arrangements offered. This initiative would ideally also incentivize departments to invite women to be speakers and thus, become more aware of women both within and outside academia who may be appropriate for job openings (48).

In listing these ideas, we acknowledge that we may have missed some strategies that have been implemented, and it is also possible that innovative strategies such as these have been implemented, but perhaps data have not been collected or broadly disseminated regarding the effectiveness of the strategy.

Steps for Moving Forward

As we have detailed in this piece, there are many strategies for reducing gender bias in STEM being explored by most key stakeholders within science, medicine and academia including funding bodies, journals, professional societies, academic institutions, and medical practices. Some strategies are aimed at gender disparities overall, and some are meant to address the exacerbation of such disparities secondary to the COVID-19 pandemic. However, there are still others we have suggested that have not yet been implemented, to our knowledge. Ultimately, what we call for, using our collective voices within academia, medicine and science, is data, then action, followed by more data and improved action. Institutions must learn where they

must intervene, then commit to funding and implementing policies and programs aimed at addressing disparities but importantly also commit to iteratively evaluating which policies are working and which ones are not (Figure 1).

It is worth noting that strategies must be put in place to ensure other aspects of diversity in STEMM, including racial/ethnic diversity and intersectional identities. While a detailed review and discussion of strategies to address disparities beyond gender in STEMM is out of the scope for this paper, the intersection of gender with other traditionally marginalized identities clearly compounds inequities in STEMM. Strategies for advancing women must not come at the expense of other diversity, equity, and inclusion initiatives.

The careful reader will note that we did not include individual-level changes for women to make, to address disparities. In 2013, Sheryl Sandberg focused the conversation around women in the workforce with two simple words: “Lean in.” The Facebook Chief Operating Officer’s bestselling book (78) sent the message that women can tackle gender inequity by overcoming what she described as their “internal barriers”, such as lack of confidence or a hesitance to negotiate, that prevent women’s rise to the top. Encouraging women to “lean in” can sound empowering, but this message places too much of responsibility for achieving gender equity on women and even worse, this message implies that women created these problems. This distinction is essential since research has made it clear that women’s behaviors are not the root of gender inequities (79, 80), rather it is the systems, policies, and widespread biases that have created this situation.

Thus, it is now time for all funding bodies, institutions of higher education, professional societies, journals, medical practices, etc. to ‘lean in.’ The fallout from the COVID-19 pandemic

has the potential to impact women in STEMM in 2020, 2021 and for many years to come. As such, all of us, in our various capacities (e.g., professional society members, administrators, editorial board members) must act now to collect the necessary data, assist women in STEMM in making up for any ground lost during the pandemic with innovative programs and policies such as the ones listed above, and thus, set up secure scaffolding for gender equity within STEMM in the years to come.

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Table 1. Summary of Strategies Reviewed and Additional Strategies to Consider

	Promising programs that have been recently implemented	Strategies to address gender disparities which have not been broadly implemented and merit evaluation
Funding Bodies	<ul style="list-style-type: none"> Tracking the impact of gender on funding (<i>National Institutes of Health</i>) (11) Implementation of early career caregiver supplemental funding to facilitate success with research grants (<i>National Institutes of Health</i>) (12) (13) (14) 	<ul style="list-style-type: none"> Broaden the use of strategies for eliminating bias in the funding review process Establish funding for testing diversity, equity and inclusion strategies
Journals	<ul style="list-style-type: none"> Prioritizing reviews of manuscripts by women (<i>International Journal of Urban and Regional Research</i>) (15) Tracking the representation of authors and reviewers to improve diversity of perspectives (<i>Lancet Group</i>) (18) Prioritizing women on editorial boards (<i>Lancet Group</i>) (18) 	<ul style="list-style-type: none"> Eliminate unprofessional or biased reviewer comments on manuscripts Increase awareness about gendered citation practices
Professional Societies	<ul style="list-style-type: none"> Tracking and increasing gender diversity in membership and leadership (<i>The Obesity Society</i>) (23) Establishing caregiver travel grants for annual meetings (<i>American Society of Nutrition</i>) (28) Pledging to eliminate “manels” (<i>National Institutes of Health, Nature</i>) (31) (32) 	<ul style="list-style-type: none"> Facilitate attendance at annual meetings Track and increase diversity of professional society awards
Colleges, Universities, and Medical Practices	<ul style="list-style-type: none"> Provision of funding to remove obstacles to productivity (<i>Lehigh University</i>) (33) Provision of pandemic-related course releases for research recovery (<i>Stanford University</i>) (34) Extending expiration dates on start-up funds (<i>Utah State University</i>) (35) Recognition of additional measures of professional success (<i>Indiana University-Purdue University Indianapolis</i>) (37) Testing the effectiveness of COVID-19 impact statements in tenure and promotion processes (<i>University of Massachusetts-Amherst</i>) (40) 	<ul style="list-style-type: none"> Implement specific funding for pandemic research recovery Eliminate gender bias in evaluations Increase visiting speaker diversity

	<ul style="list-style-type: none">• Bolstering strategies for the recruitment of women to STEMM positions (Athena SWAN Initiative) (53)	
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Figure Legend:

Figure 1: Fundamental Principles in Addressing Gender Disparities in Science, Technology, Engineering, Math, and Medicine

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