



Facilitating the Success of Women's Early Career Grants: A Local Solution to a National Problem

Chatanika Stoop¹ · Rebecca Belou² · Jessi L. Smith³

Accepted: 1 June 2023 / Published online: 7 July 2023
© The Author(s) 2023

Abstract

Grant funding is essential to the advancement of science, technology, engineering and math (STEM) fields with certain grants viewed as especially prestigious and career formative. The goal of this project was twofold: first to describe the gender demographics of the national winners of two prestigious grants and second, to document the impact of an educational program aimed at improving the success for women in STEM fields in a local setting. In Study 1, we analyzed publicly available national data to document gender gaps in National Science Foundation's Faculty Early Career Development Program (CAREER) and National Institutes of Health's K01 awards from 2008–2021. Results showed that, while the ratio of K01 awards favored women, the ratio of men-to-women CAREER awardees favored men. In Study 2, we implemented a grant-writing program for CAREER awards based in self-determination theory at one university and analyzed its impact on funding success. Results comparing before the educational program and after showed that the average annual success rate increased for everyone from 11% to 33%. Women-identified faculty who participated in the program were awarded CAREER funding at a higher rate than would be expected from the number of women eligible to apply or submission rates. While the correlational and observational nature of this study make it impossible to conclude that it was only the educational programs that resulted in the benefits to women's award success, we encourage other universities to consider adapting the program and enable faculty development around grant success.

Keywords CAREER · Funding · Education · Faculty · Gender · Equity

✉ Chatanika Stoop
nikastoop@montana.edu

¹ Center for Faculty Excellence, Montana State University, Bozeman, MT 59717, USA

² Office of Planning and Analysis, Montana State University, Bozeman, MT 59717, USA

³ Office of Research, University of Colorado, Colorado Springs, CO 80918, USA

Introduction

As the United States continues to face the challenge of growing a robust and diverse scientific and engineering workforce, federal funding agencies have, for more than two decades, set a priority for more inclusion of women in academic STEM (Laursen & Austin, 2020; Mervis, 2000; Morimoto et al., 2013; Roper, 2019; Valantine & Collins, 2015; Valantine et al., 2016). From establishing funding portfolios (e.g., the National Science Foundation ADVANCE program) to creating advisory boards (e.g., the NIH Working Group on Diversity), major federal funding agencies in the U.S. are committed to ensuring that the talents of marginalized and minoritized scholars are part of scientific discovery and innovation.

The purpose of the current study was to inventory national-level award recipients and identify gender disparities in prestigious early career funding awards and implement and assess a local program to improve women's funding success. To do this, first, we described the national pattern of gender demographics of those who have won two types of prestigious grants across the nation. Second, we documented the impact of a local in-house educational program aimed at improving the funding success for one type of prestigious grant for women-identified faculty in STEM fields. For both the national and local outcomes, we examined patterns across time.

In most countries (including the U.S.), men-identified researchers still receive more sponsored programs or grant awards on average than women-identified researchers (Bedi et al., 2012; de Kleijn, 2020; de Kleijn et al., 2020). For example, according to one analysis of well over 100,000 applications, women-identifying researchers had significantly lower odds of receiving grant funding from the National Institutes of Health (Eblen et al., 2016). Add to this, that women receive about \$40,000 less in funding in first time NIH grants compared to their male-identifying counterparts (Oliveira et al., 2019) and have a lower likelihood to get grant renewals funded (Kaatz et al., 2016). However, it is not all a bad news landscape: analyses of proposals using FY2020 data from the National Science Foundation (NSF) shows an overall success rate of 32% for women (vs 29% for men) for all types of proposals. Despite the somewhat higher funding rates for women at NSF, submission data indicate that “over the past decade, there has been a relatively slow increase in the proportion of proposals submitted by women and a corresponding increase in the proportion of awards to women” (National Science Foundation [NSF], 2021). Given the overall persistent underrepresentation of women-identified faculty within U.S. universities, especially within math-intensive fields such as engineering where women are only 16.6% of tenure/tenure track faculty (National Center for Science and Engineering Statistics, 2022), every woman who does submit and receive an award is a win for inclusive discovery and innovation.

There is no one obvious culprit for the persistent gender inequity in grant activity. Explanations range from macrolevel systematic inequities whereby unwritten rules and bias are integrated into the very structures of academia and funding agencies (Morgan et al., 2018; Niemann et al., 2020) to microlevel inadequacies that limit women's access to grant administrators to support their submissions (e.g., (Holliday et al., 2015) with many other variables in between. With the goal

of facilitating the careers of minoritized and early-career faculty, agencies have responded in varied ways including training reviewers (Merit Review Process FY 2020 Digest, 2021), revising solicitations and review protocols (Witteman et al., 2021), raising the cut-off age for early-career awards (Mervis, 2017) and changing biosketch formats (Rockey, 2014). While these broad system-level approaches to equity are essential, they take time to show incremental improvements. Inspiring the question: what deliberate actions can a university take in the meantime?

Recruiting diverse talent is one (necessary) step in the equation (Rockey, 2014) with the help of empirically-based interventions that broaden participation through the faculty hiring process (Allen et al., 2019; Sheridan et al., 2010; Smith et al., 2015). But even among highly successful and qualified women-identifying faculty, grant proposal submission rates are often lower, especially among women of color (Ginther et al., 2016; NSF, 2021). Women-identifying researchers can also feel more deterred by grant-reviewer feedback that interferes with their intentions for resubmitting (Biernat et al., 2020). Thus, one strategy is to offer hands-on educational resources to support women-identified faculty's grant submission process.

One example of such a strategy was the creation of a theory-informed “grant-writing bootcamp” tested over time at one university (Smith et al., 2017). This university was the recipient of the National Science Foundation ADVANCE institutional transformation grant, with the aim to enhance the research opportunity for women in STEM and social and behavioral science (SBS) fields. The programs developed by ADVANCE Project TRACS (Transformation through Relatedness, Autonomy, and Competence Support) were based within the tenets of self-determination theory (Deci & Ryan, 2012). This theory articulates fundamental “needs” for motivation as 1) competence – the need to understand the logistics and processes for completing a task successfully, 2) autonomy – the capacity for choice and influence over tasks and decisions, and 3) relatedness – building networks and feeling a sense of belonging. The bootcamp was designed using self-determination theory and resulted in a significant increase in the number of proposals submitted by women as PI, a significant increase in the number of grants funded, and in the amount awarded.

The Smith et al. (2017) grant-writing bootcamp quasi-experiment did not distinguish between the type of external funding awarded. All awards were treated as the same positive outcome. Yet, it is certainly the case that some federally funded grants are more prestigious than others, especially for early-career faculty, and may be prone to different gender-gaps. The NIH K award and NSF Faculty Early Career Development Program (CAREER) are two examples of highly regarded awards in the U.S. that not only provide funding for the intellectual project at hand, but also convey reputational benefits for the recipients (Gallus & Frey, 2017) and their institutions.

Research Questions

Given that women-identifying faculty are often passed over for research prizes and awards (and when they do win, they often do not garner as much attention (Lunne-mann et al., 2019; Ma et al., 2019; Meho, 2021; Watson, 2021)), we asked two related research questions, one at the national level and one at the local level. In Study 1, we

asked if there was a difference in the proportion of men and women recipients of the NIH K awards and the NSF CAREER awards across the nation over the last 10 years. This analysis is similar to a recently published NSF meta-research study that showed racial disparities for funding rates of research proposals are hidden when considering the overall funding rates for all proposals (Chen et al., 2022). With results pointing to a significant discrepancy in the gender distribution of the NSF CAREER awards, Study 2, implemented a local level educational program modeled after the evidence-based grant-writing bootcamp (Smith et al., 2017) to determine:

1. Can we close the gender-gap in NSF CAREER submissions and awards found at the national level?
2. Can we associate participating in the grant-writing educational opportunity with grant funding success?

Study 1: National Descriptive Study of Early Career Award Winners

Overview

The purpose of Study 1 was to describe the gender demographics for prestigious grants that have a significant impact on the success of early-career faculty. Two funding opportunities were identified because of their impact and publicly available awardee data. The NSF CAREER Program is a prestigious award that supports early-career faculty by encouraging integration of research and education, preparing them to lead advances in the mission of their department or organization. The K awards program, specifically the K01 Mentored Research Scientist Career Development Award, provides support and protected time for an intensive, supervised career development experience in the biomedical, behavioral, or clinical sciences. The goal is to enable early-career faculty to become independent researchers and some NIH institutes use the award to increase workforce diversity, encourage individuals to consider training in a new field, or to support returning to the research workforce.

Methods

Participants Publicly available data from the NSF and NIH websites were mined for award recipient information of the NSF CAREER Awards and NIH K awards, spanning years 2008 to 2021. Data containing the names and affiliation for each awardee were downloaded into an excel file from NSF and NIH Awards public websites accessed in October 2021. The sample sizes were 2,829 records for NIH K awardees and 2,807 for NSF Career awardees between 2008 and 2021.

Procedure Data were then coded by a research assistant, naïve to the study goals, who looked up the awardees profile on publicly available websites to determine

pronoun use and infer the awardee’s gender (men-identifying, woman-identify, non-binary/unknown). A total of 67 (2.3 % of the NIH) and 96 (3.4% of the NSF) awardees could not be located and were therefore not included in the analysis.

Results

Analysis Overview Given our goal was to describe the pattern of award winners by gender, we used a combination of inferential and descriptive analyses in Study 1. The gender ratio was determined by dividing the number of women by the number of men who were awarded either NIH K01 or NSF CAREER grants. Those who were in the unknown/non-binary category were not included in the calculation. These ratios were graphed on the same axes with a solid line in the center at 1 where the number of awardees by gender is equal. We also calculated the regression line to determine the best fitting line for the longitudinal data. Such an approach helps us to unpack the trends in national awards by awardee binary gender.

Pattern of Awardee Gender Similarities and Differences The ratio of the number of women-to-men early-career research grant awardees by agency is shown in Fig. 1. While the ratio of NIH K01 awardees has been consistently favoring women ranging between 1.03 and 1.69 (above the “parity line” horizontal line Fig. 1), the ratio of men-identified awardees to women-identified for NSF CAREER awards has varied

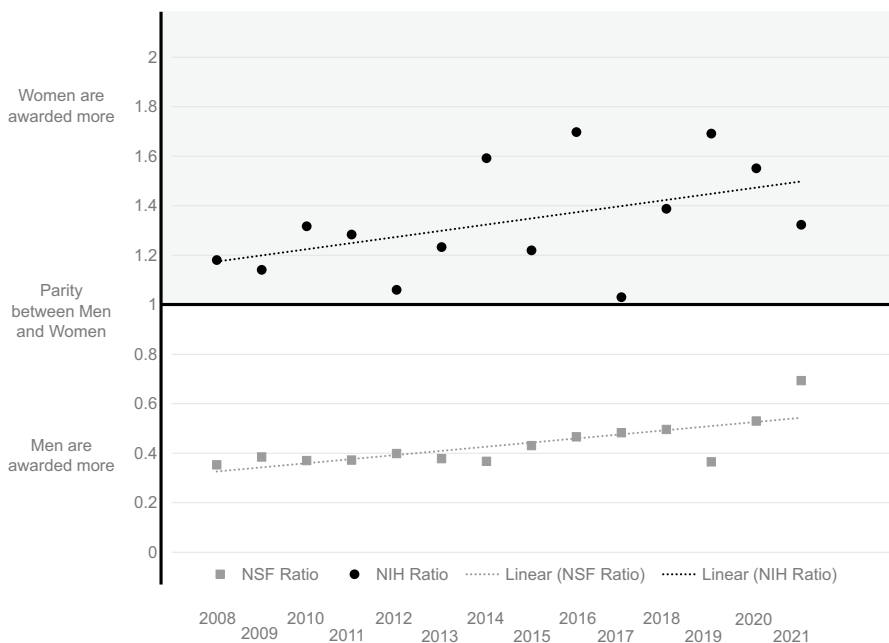


Fig. 1 Pattern of Awardee Gender overtime for NIH K01 awards and NSF CAREER awards

between 0.37 and 0.69. The dotted line indicates the linear regression which is increasing in slope for both grant programs. As shown in Fig. 1, ratios above 1 indicate that women scientists are receiving a higher share of the awarded NIH K01s. In contrast, in no year did men and women achieve parity in the NSF CAREER awards.

Figure 1 Ratio of women to men awardees calculated for each year 2008 - 2021. The horizontal black line indicates where parity is achieved between women and men. Data is from NSF and NIH Awards public websites accessed October 2021.

Limitations and Discussion

Study 1 was limited in that we could not consider the number of proposals submitted or the number of men and women faculty eligible to submit from a given university. To be eligible for the CAREER awards for example, faculty must hold a doctoral degree in a field supported by NSF; be engaged in research in an area of science, engineering, or education supported by NSF; and be untenured at the time of submission (see solicitation for the complete list of requirements). Indeed, by one estimate, success rates have increased at NSF as the annual number of applications has declined (Mervis, 2022). Another limitation is that the determination of the gender of awardees was a very labor-intensive process and resulted in grouping those who identified as non-binary with those whose gender could not be determined from their websites. They are also limited to binary categorizations of gender (as men and women) and do not offer any information about intersectional identities such as the benefits to Black, Indigenous and Other People of Color (BIPOC) faculty. While the number of awardees for each award were fairly similar, more awardees were removed from the calculations from NSF (3.4%) versus NIH (2.3%).

Overall, these national results suggest that the pattern of more men-identifying than women-identifying researchers receiving the prestigious NSF CAREER early-career award is consistent over the past decade. Therefore, Study 2 focused on the NSF CAREER funding opportunity and examined the efficacy of a theoretically-informed educational program to close the gender gap.

Study 2: Local Descriptive Study of Educational Program

Overview

The purpose of Study 2 was to assess whether designing a targeted educational program focused on the NSF CAREER award could close the gender gap between men and women early-career award recipients at one university. Based on the tenants of the evidence-based “Grant-Writing Bootcamp” (Smith et al., 2017), developed as part of the NSF ADVANCE Institutional Transformation program (2012 – 2018), the program for Study 2 was designed to address women researchers’ unique psychological needs for relatedness, competence, and autonomy (Deci & Ryan, 2012;

Smith et al., 2018) though it was open to all identities depending on space availability. The design enhanced autonomy by allowing faculty to take creative approaches with topics, methods, and timing; competence by providing advice, tools and templates for navigating the grant paperwork and submission process; and relatedness by creating small groups of peers and connections to grant-successful mentors. The program was implemented starting in 2015. Therefore, the analyses are calculated on and compared between pre- and post-time periods, seven years before the program and seven years after the program began respectively.

Methods

Participants Participants for the analysis were retrospectively identified by gathering data from research.gov for the local institution. We gathered data for seven years (2008 – 2014) before the implementation of the local program (pre) and seven years (2015 – 2021) after the implementation of the program (post). While the list of awardees goes back to 1994, data about submissions is only available starting in 2008 when electronic submissions began. Overall, we had 75 individuals who submitted proposals over the 14-year period, 35 of which submitted multiple proposals to equal 115 observations in the study. The sample sizes for submissions were $n = 53$ for the pre-time period and $n = 62$ for the post-time period. The number of awardees were $n = 7$ from the pre-time period and $n = 16$ for the post-time period (Table 1). In addition to the participant award status, we collected data from the internal university system that allows participants to register for and record attendance of many types of professional development workshops and activities. These numbers are indicated as to whether participants attended (yes) or did not attend (no, Table 2). We also collected data from the Institutional Research office regarding the self-reported genders of the participants. All participants self-identified to the university as man or woman, with no one identifying as non-binary.

Table 1 Descriptive statistics of submission, awards, success rate and eligible faculty pre and post education program

	Gender	pre	post	Fold change
Number of Submissions	ALL	53	62	1.2
	M	42	31	0.7
	W	11	31	2.8
Number of Awards	ALL	7	16	2.3
	M	5	7	1.4
	W	2	9	4.5
Average Annual Success Rate	ALL	11%	33%	3.0
	M	10%	27%	2.6
	W	10%	36%	3.8
Average Number of Faculty	ALL	157.6	180.3	1.1
	M	84.4	77.7	0.9
	W	73.1	102.6	1.4

Table 2 Raw data and odds ratios associations with faculty gender and CAREER program attendance with award success

	Awarded CAREER Award					
	All		Men		Women	
Attended CAREER Panel	Yes	No	Yes	No	Yes	No
Yes	13	29	5	15	8	14
No	10	63	7	46	3	17
Odds Ratio	2.82		2.19		3.24	

Procedure We developed and implemented a targeted educational program to support all faculty who were submitting to the NSF CAREER programs based on the grant-writing bootcamp. Bootcamp was set up to address women researchers' unique psychological needs for relatedness, competence, and autonomy (Deci & Ryan, 2012; Smith et al., 2018) though it was open to all identities depending on space availability. The design enhanced autonomy by allowing faculty to take creative approaches with topics, methods, and funding sources; competence by providing advice, tools and templates for navigating the grant paperwork and submission process; and relatedness by creating small groups of peers and connections to grant-successful mentors. Bootcamp spans 5 to 6 weeks with one 3-hour session per week. Participants engage in discussions with guest faculty each week on different topics and give peer feedback on homework assignments. The facilitator reviews “homework” assignments between sessions and gives feedback to the participants. In the last session, participants bring the revised elements of the grant along with at least the first three pages of their narrative for a review session with an expert in their area of research. For more information on the original bootcamp, see Smith et al. (2017).

Similar to the general grant-writing bootcamp described in Smith et al. (2017), the CAREER Program incorporates a panel session and workshop with previous successful CAREER awardees and connects faculty in review groups (to meet the psychological needs of autonomy and relatedness); and provides access to successful proposals and grant proposal submission assistance from grant support staff (to facilitate the need for competence). A complete description of the program is available on our website (<https://www.montana.edu/facultyexcellence/research/resources/nsfcareerprogram.html>). The program has since expanded, initially including a panel session and access to proposals, it now includes review groups that often meet once a week until the submission date to give feedback and help with accountability. The program has also added the ability to arrange external reviews and has run yearly for a total of seven years.

Results

Analysis Overview To meet the goals of Study 2, we employed Chi-Square as the nonparametric analysis to determine any differences in funding success after

participation in the educational program paired with the calculation of an odds ratio and basic descriptive data to unpack the direction and strength of the success rate. This approach allowed us to examine our research question about the association of award success with faculty's gender and participation in the faculty development program.

Variables We used one dependent variable in our analyses, whether a faculty member was awarded or declined and two independent variables, Gender (Men = 0, Women = 1) and CAREER Panel attendance (Did not attend = 0, Attended = 1). The awarded/declined data was gathered from [Research.gov](https://www.research.gov). Because of the length of the grant review process, proposals were submitted in one year and then reviewed and awarded in the next calendar year. Therefore, the data were reported based on the submission year. For example, if a proposal was submitted in 2015 and awarded in 2016, then the data was counted as a 2015 submission that was awarded. Using this data, we calculated the average annual success rate by gender, the number awarded divided by the number of submissions, for each of the seven years (Table 1). Next, we calculated the overall average annual success rate for the pre- and post-time periods. We also calculated the fold increase in women-identifying faculty at the institution since the goal of the ADVANCE project was to increase that number and therefore could have impacted the overall numbers.

Odds Ratio Taking a retrospective look at the data, we used the odds ratio calculation to assess the how strongly an event (receiving the CAREER award) is associated with exposure (participation in bootcamp or the CAREER program, Table 2). The odds ratio is a ratio of two odds: the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure (Szumilas, 2010). For example, Smith, Vidler and Moses used the odds ratio to explore the impact of gender on choosing to stop the tenure clock due to COVID (Smith et al., 2022). In the case of our study, we calculated the odds ratio as (# awardees who attended/# of awardees who did not attend)/ (# declines who attended/# declines who did not attend). Values above 1 indicate that attending the professional development program increased the odds of being awarded a CAREER grant.

Closing the Gender Gap Table 1 shows the submissions, awards, average annual success rate and average number of eligible faculty in the pre- and post-time educational program periods. Inspection of descriptive patterns show that the overall average annual success rate for all faculty increased from 11% to 33%. In particular, the number of women faculty awardees has grown from 2 between 2008 – 2014 to a total of 9 awardees between 2015 – 2021, representing a 4.5-fold increase. For all faculty, the number of submissions increased 1.2-fold (pre n = 53, post n = 62), and the awards increased 2.3-fold (pre n = 7, post n = 16).

Inspection of the descriptive patterns suggest that women-identified faculty improved in their success rate from pre to post educational program. They submitted a total of 11 proposals before the program and increased to 31 over the seven years

since the start of the program. These numbers mean that on average, women are submitting 2.8 times more proposals, while the number of eligible women faculty at the institution has increased by only 1.4-fold. The most significant observation is that, not only did number of submissions increase, but women-identifying faculty's average annual success rate also increased from 10% to 36% after the implementation of the program (Table 1).

That is not to say that men did not benefit from the program. The success rate for men increased from 10% to 27%. While the average number of submissions has decreased, men faculty saw a 1.4-fold increase in the average number of awards in the years after the implementation of the program (Table 1). Similar to other gender-equity initiatives (Smith et al., 2018), this program designed to support women-identified faculty results in closing the gender gap while also fostering success for everyone engaged no matter their gender-identity.

Success Rate Increase is More than Expected based on the Increase in Women Faculty

The goal of the ADVANCE Project TRACS was to transform the University and increase the number of women faculty in STEM and underrepresented areas of Social and Behavioral Science (SBS). This increase in numbers of faculty might then be expected to increase the number of CAREER awards for women faculty, and it does. But, as shown in Fig. 2, there is evidence that the fold increase of submissions (white boxes) and awards (black boxes) are significantly higher in the observed than the increase in women-identifying faculty (1.4 times the pre-time shown in “Expected”). The average annual success rate therefore takes into account the increase in the number of submissions, and we see that it increased from 10% to

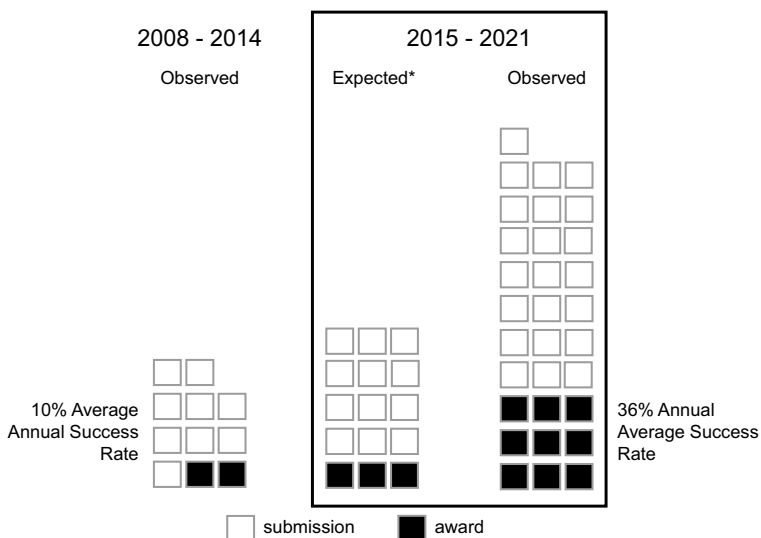


Fig. 2 Data Visualization of the Impact of Increased Number of Women-Identified Faculty on CAREER Award Success Overtime

36% representing a 3.6-fold increase suggesting that the growth of women-eligible faculty is not the sole reason for the improvement in CAREER award outcomes.

Figure 2 Illustration of the predicted and observed outcome based on number of women faculty. The white boxes (unfilled) represent submissions, the black boxes (filled) represent awards from those submissions. The outlined area shows the data after the implementation of the program (2015–2021). The expected column (*) shows the increase that could be attributed to increase in faculty numbers (1.4), whereas the observed in this post-time period shows the increased submissions, awards and success rate that could be attributed to the program.

Attending the CAREER Program and Funding Success While the timing of the increase success rate aligns with the implementation of the CAREER program, it also coincides with the implementation of bootcamp and other ADVANCE programs, as such, we first used Chi-Square as a nonparametric analysis comparing frequency counts to assess if award outcomes were associated with faculty gender and participation in the educational program. Results showed a meaningful difference of these factors at $X^2(1, n=115) = 4.96, p < .03$. We used odds ratio to determine the direction and strength of the impact and explore if those who attended the theory-informed NSF CAREER educational program had greater odds of being awarded funding (Table 2). Inspection of the odds ratio, a measure of how strongly an event (being awarded) is associated with exposure (to the educational program), suggested that all faculty increased their odds of being awarded a CAREER grant by 2.82-fold if they attended the program. The odds were even greater for women-identified faculty at 3.24-fold.

These follow-up data give some indication of the connection among the variables and suggests the local educational program is one promising strategy to close the gender-gap in NSF CAREER awards. Because women-faculty were intentionally invited to attend the educational program (and were given first refusal to attend rights, in what was otherwise a space limited program) there is a confounding variable between attendance in the program and faculty gender. Future research would do well to randomly assign faculty to the program to determine a causal effect of participation.

Limitations and Discussion

There are several limitations in Study 2, both because of the observational and retrospective nature of the analysis and the binary nature of the data. We could only measure the participation in the CAREER panel and not the other aspects of the program, such as the access to successful proposals or peer writing group participation. While this hints at a direct impact, the correlational and observational nature of this study make it impossible to conclude that it was only the CAREER Program that resulted in the benefits to women-identified faculty's award success. It could be that many of the ADVANCE Project TRACS programs (e.g., Smith et al., 2018), including the grant-writing bootcamp that has already shown to have an impact (Smith

et al., 2017), or still yet other activities in combination at the local level contributed to the increase in funding success.

General Discussion

Advancing the discovery of new knowledge is critical to the health of the planet and the public. Funding agencies are committed to the intentional inclusion of women's voices to that discovery process, with varying success over time (e.g., Bedi et al., 2012; Bornmann et al., 2007; Hechtman et al., 2018; Ley & Hamilton, 2008; Marsh et al., 2009). Women-identified faculty who are early in their career are especially likely to face barriers and biases as they navigate the academic pathway (Barfield et al., 2016; Fox Tree & Vaid, 2022; Muradoglu et al., 2021; Niemann & Gonzalez, 2020; Skewes et al., 2018; Williams, 2000). Our goal was to look at the national trends in prestigious grants and determine if there were a place to intervene at the local level for a local impact. First, we reviewed the data for gender gaps in prestigious awards to early-career faculty within two funding agencies: The NIH K01 awards and the NSF CAREER awards. Results demonstrated that while women received the majority of NIH K01 awards over the last 14 years, NSF CAREER awards were consistently more likely to go to men.

Our results cannot speak to why the NIH gender-gap favors women-identifying researchers. Could it be because the NIH K awards focus on mentoring, or because more and more women are entering the life science workforce, or because of efforts by NIH to improve processes that support women submissions? Similarly, our data cannot say why NSF CAREER awards were more likely to be granted to men-identifying researchers. However, documenting the gender gaps (and the direction of effects) is useful to consider when prioritizing the content of educational programs that broaden the participation of women and BIPOC faculty researchers. We therefore set out to explore the impact of an educational grant-writing program based on self-determination theory (Deci & Ryan, 2012), part of the ADVANCE Project TRACS, and specifically designed to benefit women-identified researchers while also allowing anyone to participate and benefit no matter their gender identity.

Data from seven years before and after the CAREER Program demonstrate promising results, and the increased average annual success rates, much more than the increase in women faculty, illustrate that the mere presence of more women is not the sole reason for the improvement over time (though it is one important aspect in women's participation in STEM, (Mitchneck et al., 2016). Of course, identifying any one causal explanation for improvement is not possible with this natural observational study; there were several additional gender-equity initiatives at this university (from 2012 – 2018) that contributed to an overall inclusive culture for women-identified faculty (Hughes et al., 2022; Smith et al., 2018). The data from professional development participation shows that women awardees who participated in the CAREER program were more likely to be awarded this prestigious grant (Table 2). This analysis is similar to a study by Glowacki et al. (2020) where they connected attending grant-writing workshops with internal grant success. While this hints at a direct impact, it is impossible to conclude that the benefits to women's award success

were solely because of the CAREER Program. However, given the very targeted focus of the educational program on CAREER awards, definition of success (submissions, awards and success rate) and using the same theoretical underpinnings of the evidenced-based grant-writing bootcamp, the findings suggest a promising strategy for other universities interested in increasing women-identifying faculty's early-career funding success.

We acknowledge that the findings are limited to binary categorizations of gender (as men and women) and do not offer any information about intersectional identities such as the benefits to BIPOC faculty, faculty who identify as sexual minorities, or faculty with different abilities. Future research should consider creating programs that facilitate the success of marginalized faculty in addition to gender and assessing the efficacy of the program at different universities.

Implications for Adopting and Adapting the CAREER Educational Program There are other educational programs that also aim to support faculty in pursuit of CAREER awards (e.g., Colorado State University and University of Central Florida to name just two). What sets the current program apart is the explicit goal to improve women-identified faculty's success and the tracking of data to that effect using a theoretically-informed educational intervention. Often, most faculty development programs and assessment is done on the impact of professional development on faculty teaching rather than research metrics such as funding success (Hoffmann-Longtin et al., 2019). Urging educational leadership and development programs to consider new areas of faculty need is one important implication of the current project.

The aim of this project was twofold: document gender gaps in prestigious funding program awards to early-career faculty and evaluate the efficacy of an innovative educational program at increasing the success of women-identified faculty. Learning materials are provided on our website (<https://www.montana.edu/facultyexcellence/research/resources/nsfcareerprogram.html>) to enable other universities to adopt this educational program. However, moving to a new research context, will likely require some adaption. We suggest that adaption would be most impactful if it is guided by the tenets of Self Determination Theory (Deci & Ryan, 2012; Smith et al., 2017). For example, this program was set up such that advice and support from successful awardees form the basis of the program, supporting relatedness and competence. If an institution is an emerging research university, primarily undergraduate institution or other context that does not have a critical mass of past awardees, they could partner with another institution to start the program and then, as they have successful awardees, transition to their own faculty. Given that competition between universities might discourage such partnerships, NSF as an agency could consider developing intentional strategies to support women-identified faculty interested in applying for a CAREER award by adapting our program (or others like it) at scale.

This CAREER Program is adaptable, not just to other universities or agencies, but to the emerging needs of the campus and context. During the height of the COVID-19 pandemic for example, the CAREER Program was run virtually. As more and more evidence emerges showing the deleterious immediate and long-term impacts of the pandemic on women faculty's research careers (Cardel et al., 2020; Carr et al., 2021; Malisch et al., 2020; Staniscuaski et al., 2021; Vincent-Lamarre et al., 2020),

it is paramount that we attend to the changing needs of women-identified faculty, especially those who are caregivers, to provide flexibility in timing, deadlines, and format for their professional development.

Finally, the implications for this study rest in the long-term benefits associated with the new discoveries that emerge, the economic and learning opportunities for the students and staff involved, and the impact on women's careers after receipt of a prestigious award. Unfortunately, research shows women who win research prizes do not receive the same acclaim as men (Ma et al., 2019) and are less likely than men to receive invitations to present their research (Nitttrouer et al., 2018; Young et al., 2018). For example, among engineering women faculty who publish in prestigious journals, their work is cited less often than men's research (Ghiasi et al., 2016). As such, it will be important to follow the career trajectories of NIH K01 winners and NSF CAREER winners over time.

In Closing Ensuring the intellectual contributions of women in STEM are recognized, valued, and rewarded is a complex problem without an easy solution. Gender-equity institutional change strategies abound (Laursen & Austin, 2020) and yet change is still slow (Stewart & Valian, 2018) and can feel daunting and overwhelming (Posselt, 2020). We set out to first define the scope of the possible problem within the space of prestigious awards at NIH and NSF, and to develop and assess a targeted educational program as one strategy to close the identified gender-gap. The results of the CAREER educational program showed women-identified faculty not only submitted more proposals over time, received more awards, but, most importantly, had higher success rates than before the program started. Though there are many possible explanations for the improvement, we encourage others to consider adopting and adapting the program keeping in mind the tenets of relatedness, competence, and autonomy (Deci & Ryan, 2012; Smith et al., 2017). Doing nothing guarantees the status quo will continue (Jost et al., 2004), and trying to solve a national problem with a local solution is but one proactive tool to impact change.

Acknowledgments This project was funded by the National Science Foundation under award Grant No. 1208831 and under Grant No. 2117351, awarded to the senior author. Any opinions, findings, and conclusions or recommendations expressed in this manuscript are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors wish to extend thanks to the student research assistants who provided data coding.

Author's Contributions **Dr. Chatanika Stoop:** Dr. Stoop currently serves as Assistant Director for the Center for Faculty Excellence and Program Lead for Gender Equity in the Office of Diversity & Inclusion at Montana State University (MSU). Dr. Stoop graduated from Yale University with Ph.D. in Molecular Biophysics and Biochemistry. Dr. Stoop leads programs, training and workshops for faculty at MSU. Dr. Stoop oversaw the program and lead the acquisition of data, analysis and/or interpretation of data, and participated in drafting, revision, and final approval of the manuscript.

Rebecca Belou, MPA: Rebecca Belou currently serves as Senior Data Scientist for the Montana State University, Office of Planning and Analysis and formerly served as Equity Data Analyst on the NSF ADVANCE Project TRACS Social Science Research Team. Ms. Belou participated in acquisition and analysis of data as well as drafting, analyses, and final approval of the manuscript.

Dr. Jessi Smith: Dr. Smith is the Chief of Research and a Professor of Psychology at the University of Colorado in Colorado Springs. She was the Principal Investigator of the NSF-funded ADVANCE Project TRACS (2012-2018) upon which this study is based and is the current PI of the ADVANCE Adaptation

Project CREST upon which programs are adapted for research inclusion and equity. Dr. Smith, in consultation with the other co-authors, formed the conception and design of the study and participated in each subsequent phase to include data acquisition, analysis and interpretation of data, and drafting, revision, submission, and final approval of the manuscript.

Declarations

Competing Interests This project was funded by the National Science Foundation under award Grant No. 1208831 and under Grant No. 2117351, awarded to Smith. Stoop, Belou and Smith declare they have no financial or non-financial interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Allen, J., Smith, J. L., & Ransdell, L. B. (2019). Missing or seizing the opportunity? The effect of an opportunity hire on job offers to science faculty candidates. *Equality, Diversity and Inclusion: An International Journal*, 38(2), 160–177. <https://doi.org/10.1108/EDI-09-2017-0201>
- Barfield, W. L., Plank-Bazinet, J. L., & Austin Clayton, J. (2016). Advancement of women in the biomedical workforce: Insights for success. *Academic Medicine*, 91(8), 1047–1049. <https://doi.org/10.1097/acm.0000000000001274>
- Bedi, G., Van Dam, N. T., & Munafo, M. (2012). Gender inequality in awarded research grants. *The Lancet*, 380(9840), 474. [https://doi.org/10.1016/S0140-6736\(12\)61292-6](https://doi.org/10.1016/S0140-6736(12)61292-6)
- Biernat, M., Carnes, M., Filut, A., & Kaatz, A. (2020). Gender, race, and grant reviews: Translating and responding to research feedback. *Personality and Social Psychology Bulletin*, 46(1), 140–154. <https://doi.org/10.1177/0146167219845921>
- Bornmann, L., Mutz, R., & Daniel, H.-D. (2007). Gender differences in grant peer review: A meta-analysis. *Journal of Informetrics*, 1(3), 226–238. <https://doi.org/10.1016/j.joi.2007.03.001>
- Cardel, M. I., Dean, N., & Montoya-Williams, D. (2020). Preventing a secondary epidemic of lost early career scientists: Effects of COVID-19 pandemic on women with children. *Annals of the American Thoracic Society*, 17(11), 1366–1370. <https://doi.org/10.1513/AnnalsATS.202006-589IP>
- Carr, R. M., Lane-Fall, M. B., South, E., Brady, D., Momplaisir, F., Guerra, C. E., Montoya-Williams, D., Dalembert, G., Lavizzo-Mouray, R. & Hamilton, R. (2021). Academic careers and the COVID-19 pandemic: Reversing the tide. *Science Translational Medicine*, 13(584), eabe7189. <https://doi.org/10.1126/scitranslmed.abe7189>
- Chen, C. Y., Kahanamoku, S. S., Tripathi, A., Alegado, R. A., Morris, V. R., Andrade, K., & Hosbey, J. (2022). Systemic racial disparities in funding rates at the National Science Foundation. *eLife*, 11, e83071. <https://doi.org/10.7554/eLife.83071>
- De Kleijn, M., Jayabalasingham, B., Falk-Krzesinski, H. J., Collins, T., Kuiper-Hoynig, L., Cingolani, I., Zhang, J., Roberge, G., Deakin, G., Goodall, A., Whittington, K. B., Berghmans, S., Huggett, S. & Tobin, S. (2020). *The researcher journey through a gender lens: An examination of research participation, career progression and perceptions across the globe*. Elsevier. https://www.elsevier.com/_data/assets/pdf_file/0011/1083971/Elsevier-gender-report-2020.pdf
- Deci, E. L., & Ryan, R. M. (2012). Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. In R. M. Ryan (Ed.), *The Oxford Handbook of Human Motivation* (pp. 85–108). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780195399820.013.0006>

- Eblen, M. K., Wagner, R. M., RoyChowdhury, D., Patel, K. C., & Pearson, K. (2016). How criterion scores predict the overall impact score and funding outcomes for National Institutes of Health peer-reviewed applications. *PLOS ONE*, 11(6), e0155060. <https://doi.org/10.1371/journal.pone.0155060>
- Fox Tree, J. E., & Vaid, J. (2022). Why so few, still? Challenges to attracting, advancing, and keeping women faculty of color in academia. *Frontiers in Sociology*, 6, 1–14. <https://doi.org/10.3389/fsoc.2021.792198>
- Gallus, J., & Frey, B. S. (2017). Awards as strategic signals. *Journal of Management Inquiry*, 26(1), 76–85. <https://doi.org/10.1177/1056492616658127>
- Ghiasi, G., Larivière, V., & Sugimoto, C. R. (2016). On the compliance of women engineers with a gendered scientific system. *PLOS ONE*, 10(12), e0145931. <https://doi.org/10.1371/journal.pone.0145931>
- Ginther, D. K., Kahn, S., & Schaffer, W. T. (2016). Gender, race/ethnicity, and National Institutes of Health R01 research awards: Is there evidence of a double bind for women of color? *Academic Medicine*, 91(8), 1098–1107. 10.1097%2FACM.0000000000001278
- Glowacki, S., Nims, J. K., & Liggit, P. (2020). Determining the impact of grant writing workshops on faculty learning. *Journal of Research Administration*, 52(2), 58–83. <https://www.srainternational.org/blogs/srai-jra/1/2020/09/29/determining-the-impact-of-grant-writing-workshops>
- Hechtman, L. A., Moore, N. P., Schulkey, C. E., Miklos, A. C., Calcagno, A. M., Aragon, R., & Greenberg, J. H. (2018). NIH funding longevity by gender. *Proceedings of the National Academy of Sciences*, 115(31), 7943–7948. <https://doi.org/10.1073/pnas.1800615115>
- Hoffmann-Longtin, K., Fassett, K., Zilvinskis, J., & Palmer, M. (2019). Measuring faculty learning: Trends in the assessment of faculty development. In S. H. S. Kahn. (Ed.), *Trends in assessment: Ideas, opportunities, and issues for higher education*. Stylus Publishing.
- Holliday, E., Griffith, A. A., De Castro, R., Stewart, A., Ubel, P., & Jaggi, R. (2015). Gender differences in resources and negotiation among highly motivated physician-scientists. *Journal of General Internal Medicine*, 30(4), 401–407. <https://doi.org/10.1007/s11606-014-2988-5>
- Hughes, B. E., Smith, J. L., Bruun, M., Shanahan, E. A., Rushing, S., Intemann, K., Belou, R., Stoop, C., & Sterman, L. (2022). Department leaders as critical conduits for the advancement of gender equity programs. *Journal of Women and Gender in Higher Education*, 15(1), 41–64. <https://doi.org/10.1080/26379112.2022.2034122>
- Jost, J. T., Banaji, M. R., & Nosek, B. A. (2004). A decade of system justification theory: Accumulated evidence of conscious and unconscious bolstering of the status quo. *Political Psychology*, 25(6), 881–919. <https://doi.org/10.1111/j.1467-9221.2004.00402.x>
- Kaatz, A., Lee, Y.-G., Potvien, A., Magua, W., Filut, A., Bhattacharya, A., ... Carnes, M. (2016). Analysis of National Institutes of Health R01 application critiques, impact, and criteria scores: Does the sex of the principal investigator make a difference? *Academic Medicine*, 91(8), 1080–1088. <https://doi.org/10.1097/acm.0000000000001272>
- Laursen, S. L., & Austin, A. (2020). *Building gender equity in the academy: Institutional strategies for change*. Johns Hopkins University Press.
- Ley, T. J., & Hamilton, B. H. (2008). The gender gap in NIH grant applications. *Science*, 322(5907), 1472–1474. <https://doi.org/10.1126/science.1165878>
- Lunemann, P., Jensen, M. H., & Jauffred, L. (2019). Gender bias in Nobel prizes. *Palgrave Communications*, 5(1), 46. <https://doi.org/10.1057/s41599-019-0256-3>
- Ma, Y., Oliveira, D. F. M., Woodruff, T. K., & Uzzi, B. (2019). Women who win prizes get less money and prestige. *Nature*, 565(7739), 287–288. <https://doi.org/10.1038/d41586-019-00091-3>
- Malisch, J. L., Harris, B. N., Sherrer, S. M., Lewis, K. A., Shepherd, S. L., McCarthy, P. C., ... Deitloff, J. (2020). In the wake of COVID-19, academia needs new solutions to ensure gender equity. *Proceedings of the National Academy of Sciences*, 117(27), 15378–15381. <https://doi.org/10.1073/pnas.2010636117>
- Marsh, H. W., Bornmann, L., Mutz, R., Daniel, H.-D., & O'Mara, A. (2009). Gender effects in the peer reviews of grant proposals: A comprehensive meta-analysis comparing traditional and multilevel approaches. *Review of Educational Research*, 79(3), 1290–1326. <https://doi.org/10.3102/0034654309334143>
- Meho, L. I. (2021). The gender gap in highly prestigious international research awards, 2001–2020. *Quantitative Science Studies*, 2(3), 976–989. https://doi.org/10.1162/qss_a_00148
- Mervis, J. (2000). NSF searches for right way to help women. *Science*, 289(5478), 379–381. <https://doi.org/10.1126/science.289.5478.379>

- Mervis, J. (2017, April 26). NSF's uphill road to making prestigious early career award more diverse. *Science News*. <https://www.science.org/content/article/nsf-s-uphill-road-making-prestigious-early-career-award-more-diverse>
- Mervis, J. (2022). Odds improve for winning NSF grants, but drop in applications troubles some observers. *Science*, 376(6594), 684. <https://doi.org/10.1126/science.adc9471>
- Mitchneck, B., Smith, J. L., & Latimer, M. (2016). A recipe for change: Creating a more inclusive academy. *Science*, 352(6282), 148–149. <https://doi.org/10.1126/science.aad8493>
- Morgan, R., Hawkins, K., & Lundine, J. (2018). The foundation and consequences of gender bias in grant peer review processes. *Canadian Medical Association Journal*, 190(16), E487. <https://doi.org/10.1503/cmaj.180188>
- Morimoto, S. A., Zajicek, A. M., Hunt, V. H., & Lisnic, R. (2013). Beyond binders full of women: NSF ADVANCE and initiatives for institutional transformation. *Sociological Spectrum*, 33(5), 397–415. <https://doi.org/10.1080/02732173.2013.818505>
- Muradoglu, M., Horne, Z., Hammond, M. D., Leslie, S. J., & Cimpian, A. (2021). Women—Particularly underrepresented minority women—And early-career academics feel like impostors in fields that value brilliance. *Journal of Educational Psychology*, 114(5), 1086–1100. <https://doi.org/10.1037/edu0000669>
- National Center for Science and Engineering Statistics. *Data Explorer*. (2022). <https://ncsesdata.nsf.gov/home>
- National Science Foundation. (2021). *Merit Review Process FY 2020 Digest*. https://www.nsf.gov/nsb/publications/2021/merit_review/FY-2020/nsb202145.pdf
- Niemann, Y. F., Gutiérrez y Muhs, G., & Gonzalez, C. G. (2020). *Presumed Incompetent II: Race, class, power, and resistance of women in academia*. Utah State University Press.
- Nitttrouer, C. L., Hebl, M. R., Ashburn-Nardo, L., Trump-Steele, R. C. E., Lane, D. M., & Valian, V. (2018). Gender disparities in colloquium speakers at top universities. *Proceedings of the National Academy of Sciences*, 115(1), 104–108. <https://doi.org/10.1073/pnas.1708414115>
- Oliveira, D. F. M., Ma, Y., Woodruff, T. K., & Uzzi, B. (2019). Comparison of National Institutes of Health grant amounts to first-time male and female principal investigators. *JAMA*, 321(9), 898–900. <https://doi.org/10.1001/jama.2018.21944>
- Posselt, J. R. (2020). *Equity in Science: Representation, culture, and the dynamics of change in graduate education* (1st Edition ed.). Stanford University Press.
- Rockey, S. (2014). Changes to the biosketch. *NIH extramural nexus*. <https://nexus.od.nih.gov/all/2014/05/22/changes-to-the-biosketch/>
- Roper, R. L. (2019). Does gender bias still affect women in science? *Microbiology and Molecular Biology Reviews*, 83(3), e00018–e00019. <https://doi.org/10.1128/MMBR.00018-19>
- Sheridan, J. T., Fine, E., Pribbenow, C. M., Handelsman, J., & Carnes, M. (2010). Searching for excellence & diversity: Increasing the hiring of women faculty at one academic medical center. *Academic Medicine*, 85(6), 999–1007. <https://doi.org/10.1097/ACM.0b013e3181dbf75a>
- Skewes, M. C., Shanahan, E. A., Smith, J. L., Honea, J. C., Belou, R., Rushing, S., Intemann, K., & Handley, I. M. (2018). Absent autonomy: Relational competence and gendered pths to faculty self-determination in the promotion and tenure process. *Journal of Diversity in Higher Education*, 11(4), 366–383. <https://doi.org/10.1037/dhe0000064>
- Smith, J. L., Handley, I. M., Rushing, S., Belou, R., Shanahan, E. A., Skewes, M. C., Kambich, L., Honea, J., & Intemann, K. (2018). Added benefits: How supporting women faculty in STEM improves everyone's job satisfaction. *Journal of Diversity in Higher Education*, 11(4), 502–517. <https://doi.org/10.1037/dhe0000066>
- Smith, J. L., Handley, I. M., Zale, A. V., Rushing, S., & Potvin, M. A. (2015). Now hiring! Empirically testing a three-step intervention to increase faculty gender diversity in STEM. *BioScience*, 65(11), 1084–1087. <https://doi.org/10.1093/biosci/biv138>
- Smith, J. L., Stoop, C., Young, M., Belou, R., & Held, S. (2017). Grant-writing bootcamp: An intervention to enhance the research capacity of academic women in STEM. *BioScience*, 67(7), 638–645. <https://doi.org/10.1093/biosci/bix050>
- Smith, J. L., Vidler, L. L., & Moses, M. S. (2022). The “gift” of time: Documenting faculty decisions to stop the tenure clock during a pandemic. *Innovative Higher Education*, 47(5), 875–893. <https://doi.org/10.1007/s10755-022-09603-y>
- Staniscuaski, F., Kmetzsch, L., Soletti, R. C., Reichert, F., Zandonà, E., Ludwig, Z. M. C., Lima, E. F., Neumann, A., Schwartz, I. D. V., Mello-Carpes, P. B., Tamajusuku, A. S. K., Werneck, F. P., Ricachenevsky, F. K., Infanger, C., Seixas, A., Staats, C. C. & de Oliveira, L. (2021). Gender, race

- and parenthood impact academic productivity during the COVID-19 pandemic: From survey to action. *Frontiers in Psychology*, 12, 1–14. <https://doi.org/10.3389/fpsyg.2021.663252>
- Stewart, A. J., & Valian, V. (2018). *An inclusive academy: Achieving diversity and excellence*. MIT Press.
- Szumilas, M. (2010). Explaining odds ratios. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, 19(3), 227–229.
- Valantine, H. A., & Collins, F. S. (2015). National Institutes of Health addresses the science of diversity. *Proceedings of the National Academy of Sciences*, 112(40), 12240–12242. <https://doi.org/10.1073/pnas.1515612112>
- Valantine, H. A., Lund, P. K., & Gammie, A. E. (2016). From the NIH: A systems approach to increasing the diversity of the biomedical research workforce. *CBE—Life Sciences Education*, 15(3), fe4. <https://doi.org/10.1187/cbe.16-03-0138>
- Vincent-Lamarre, P., Sugimoto, C. R., & Larivière, V. (2020, May 19). The decline of women's research production during the coronavirus pandemic. *Nature Index*. <https://www.nature.com/nature-index/news-blog/decline-women-scientist-research-publishing-production-coronavirus-pandemic>
- Watson, C. (2021, September 21). Women less likely to win major research awards. *Nature News*. <https://doi.org/10.1038/d41586-021-02497-4>
- Williams, J. C. (2000, October 27). How the tenure track discriminates against women. *Chronicle of Higher Education*. <https://www.chronicle.com/article/how-the-tenure-track-discriminates-against-women/>
- Witteman, H. O., Haverfield, J., & Tannenbaum, C. (2021). COVID-19 gender policy changes support female scientists and improve research quality. *Proceedings of the National Academy of Sciences*, 118(6), e2023476118. <https://doi.org/10.1073/pnas.2023476118>
- Young, K., Lovedee-Turner, M., Brereton, J., & Daffern, H. (2018). The impact of gender on conference authorship in audio engineering: Analysis using a new data collection method. *IEEE Transactions on Education*, 61(4), 328–335. <https://doi.org/10.1109/TE.2018.2814613>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Dr. Chatanika Stoop Dr. Stoop currently serves as Assistant Director for the Center for Faculty Excellence and Program Lead for Gender Equity in the Office of Diversity & Inclusion at Montana State University (MSU). Dr. Stoop graduated from Yale University with Ph.D. in Molecular Biophysics and Biochemistry. Her recent work and publications focus on supporting faculty development for women in STEM and she is the co-PI on the NSF Partnership grant Values-based Leadership Trajectories for Women in STEM.

Rebecca Belou, MPA Rebecca Belou currently serves as Senior Data Scientist for the Montana State University, Office of Planning and Analysis and formerly served as Equity Data Analyst on the NSF ADVANCE Project TRACS Social Science Research Team.

Dr. Jessi Smith Dr. Smith is the Chief of Research and a Professor of Psychology at the University of Colorado in Colorado Springs. She was the Principal Investigator of the NSF-funded ADVANCE Project TRACS (2012–2018) upon which this study is based and is the current PI of the ADVANCE Adaptation Project CREST upon which programs are adapted for research inclusion and equity.