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Policy proposals to promote inclusion of caregivers in the research funding system

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Research funding is critical for scientific production and career advancement in science, technology, engineering, mathematics, and medicine (STEMM). The COVID-19 pandemic has unmasked a deeply flawed research funding system riddled by inequitable policies, biased evaluations, and a lack of transparency and accountability. While most scientists were affected by the pandemic to some extent, evidence shows that women with caregiving responsibilities were disproportionately impacted, with long-term effects on their careers. However, despite calls for change by scientists globally, whose careers depend largely on funding success, decision-makers have made little to no effort to reform a funding system that marginalises a large proportion of researchers, including women, and especially mothers. Here, we review the current literature on gender bias in the STEMM funding process and propose a set of specific, actionable policies to promote caregiver inclusion and close the gender gap in research funding.

KEYWORDS

science policy, motherhood, caregiving, gender bias, research funding, maternal wall, motherhood penalty, work-life balance

Introduction

Research funding is critical for scientific production and career advancement in science, technology, engineering, mathematics, and medicine (STEMM) academia. Securing research grants not only provides essential resources to conduct scientific research, but also improves chances for promotion to senior academic and research positions (Jebsen et al., 2020). Funding success is shown to increase the impact and number of peer-reviewed publications (Heyard and Hottenrott, 2021; Hussinger and Carvalho, 2021), promote collaboration (Pina et al., 2019; Davies et al., 2022), and boost scientific reputation and visibility (Bloch et al., 2014). In addition, being awarded a research grant increases the probability of obtaining future funding, often referred to as the Matthew effect of accumulated advantage (Bloch et al., 2014; Jebsen et al., 2022). External research grants awarded in competitive funding schemes such as the European Research Council (ERC) have become an indispensable funding source for public research institutions over the past decades (Lepori et al., 2007), further emphasising the importance of funding success for a researcher's hiring, promotion, and tenure potential.

This reliance on grant funding for career progression puts tremendous pressure on researchers to invest most of their time on writing and applying for grants and to disregard other important aspects of their jobs, as well as their personal wellbeing (Hatch and Curry, 2020). The excessive administrative workload of grant applications, combined with their low success rates (e.g., ERC Starting Grant success rate was 14.2% in 2024, for other examples see

Stadmark et al., 2020) and a lengthy peer-review evaluation process that lacks transparency and objectivity (Recio-Saucedo et al., 2022), add up to an extremely inefficient and inequitable funding system that penalises a large proportion of scientists with substantial productivity and personal costs. These enduring problems have led to outcries by researchers globally denouncing funding system flaws and asking funding agencies to improve their practices and reform the grant selection process, for example, in initiatives such as the San Francisco Declaration on Research Assessment (Bladek, 2014, see Box 1).

Importantly, relevant statistics across countries and disciplines reveal a persistent gender gap in research funding, both in award success rates and in the amount of funding allocated (Husu and de Cheveigné, 2010; Ranga et al., 2012; van der Lee and Ellemers, 2015; Jebsen et al., 2020; Witteman et al., 2019; Schmaling and Gallo, 2023). Gender differences in research funding are typically explained by the lower number of women applying for the awards, particularly for mid- and advanced-career grants (Jebsen et al., 2020). However, as funding agencies began disclosing gender disaggregated statistics of their award success rates due to growing pressures to promote diversity, equality and inclusion (DEI), a clear picture started to emerge revealing pervasive funding inequities that hold back female scientists globally (Husu and de Cheveigné, 2010; Ranga et al., 2012; van der Lee and Ellemers, 2015; Witteman et al., 2019), and particularly women of colour (Chen et al., 2022), ultimately contributing to the leadership and salary gender gap in STEMM academia.

Gender bias in research funding

A surge of research interest in the topic of gender inequity in research funding was triggered in the early 2000s by the publication of data showing that women were evaluated more harshly–and male achievements were overestimated–in grant peer-review evaluations of the Swedish Medical Research Council (Wennerås and Wold, 1997). In the following decades, several studies controlling for research proposal quality and applicant calibre provided further evidence of gender bias in the grant evaluation process across several European (Husu and de Cheveigné, 2010; Ranga et al., 2012; van der Lee and Ellemers, 2015; Bianchini et al., 2022), North American (Ley and Hamilton, 2008; Tamblyn et al., 2018; Roper, 2019; Witteman et al., 2019) and Australian national funding agencies (Borger and Purton, 2022). For female and male applicants with equivalent track records and research project quality, women were less likely to be funded and received lower scores from external reviewers and selection panels. For example, a natural experiment at the Canadian Institutes of Health Research showed that proposals evaluated based on the research project were funded roughly in equal proportions between genders, but when the review was focused on assessing the applicant, men were 1.4 times more likely to receive funding than their female counterparts (Tamblyn et al., 2018). In a research consortia pan-European funding scheme, applications from consortia with a higher proportion of female leaders were more likely to receive unfavourable evaluations both from external reviewers and expert selection panels (Bianchini et al., 2022).

In light of these findings, several funding agencies such as the ERC and the Swedish Research Council (Vetenskapsrådet) have attempted to correct these inequities and made some progress in achieving gender-equal award success rates (ratio of applicant number vs. award number). However, these efforts may conceal persistent unequal peer-review evaluations, instead of reflecting a veritable improvement in eliminating gender bias in the grant allocation process. Indeed, a recent analysis of funded and unfunded grant applications for a funding scheme of the Dutch Research Council (NWO) showed that selection panels awarded funding to women who had received unfair unfavourable scores from external reviewers to "correct" their biased evaluations (Bol et al., 2022). These findings raise two important points: (1) funding agencies are taking insufficient measures to eradicate gender bias in the grant evaluation process; and (2) some funding bodies are effectively applying implicit gender quotas to rectify these gender biases. While gender quotas are an effective and necessary tool to correct gender biases and increase women's representation in STEMM, research funders must simultaneously address the underlying issues and commit to abolishing unconscious bias at every stage of the funding process.

The maternal wall drives the STEMM leaky pipeline

Maternity bias is the strongest form of gender bias (Painter et al., 2012). Growing evidence shows that systemic barriers related to motherhood, collectively known as 'maternal wall' or 'motherhood penalty', are widespread in STEMM (Villablanca et al., 2011; Mason et al., 2013; Cech and Blair-Loy, 2019; Moors et al., 2022). These barriers contribute to the STEMM 'leaky pipeline' phenomenon, which describes the gradual decline in women's workforce participation at various career stages (Di Bartolo and Torres, 2024). The picture is clearer than ever: the STEMM sector, and academia in particular, is incompatible with caregiving. A recent study showed that 42% of mothers and 15% of fathers in the United States leave full-time STEMM employment within 3 years of having children (Cech and Blair-Loy, 2019), and our own data collected in a global survey further revealed that these trends are global (commented in Powell, 2021). These alarming statistics provide evidence that scientists with caregiving responsibilities face significant marginalisation in the STEMM sector, and mothers are disproportionately affected. However, the acknowledgment of the maternal wall by the scientific community is very recent, and the

BOX 1 Initiatives to call for a reform of the funding system.

Declaration on Research Assessment (DORA) was originally published in 2013 and contains practical advice to improve current methods of research assessment and replace inadequate metrics (www.sfdora.org).

Leiden Manifesto for Research Metrics was created by five scientists to oppose the current metric-based research evaluation system. The manifesto presents ten principles for an alternative way to measure research performance (www.leidenmanifesto.org).

Initiative for Science in Europe (ISE) is an independent organism advising on European policy endorsed by over 150 organisations. ISE published a report with 18 suggestions to reform research evaluation and put forward Open Science practices (www.initiative-se.eu).

development and implementation of effective caregiving policies is scarce (UK Research and Innovation, 2020).

Why are mothers leaving the STEMM workforce? STEMM is a traditionally male-dominated sector and maternity bias is rife and normalised in the academic community. Academic mothers are less likely to get tenure than fathers or their childless peers (Wolfinger et al., 2008; Mason et al., 2013) and suffer a salary penalty after becoming parents, while men receive a "fatherhood premium" (Kelly and Grant, 2012; Beutel and Schleifer, 2021). More subtle maternity biases may come in the form of assumptions. Employers may exclude mothers from career-advancement opportunities because they assume they are not available, often with benevolent intentions (Williams, 2005; Staniscuaski et al., 2023). For academic mothers, this typically means not being invited to participate in research projects, conferences, or meetings/events after standard working hours or which involve travelling. Motherhood has also been associated with a reduction in scientific productivity in a handful of intra-national and field-specific studies (Sidhu et al., 2009), but the underlying mechanisms remain elusive (Morgan et al., 2021; Zheng et al., 2022). As a result of these attritions, female scholars are more likely to delay or renounce parenthood and have fewer children than their male counterparts (Mason et al., 2013; Morgan et al., 2021).

Studies have persistently found strong family–work conflict in academia (Fox et al., 2011; Miller and Riley, 2021). Childcare is a task predominantly performed by women, including among academics (Jolly et al., 2014; McCutcheon and Morrison, 2016). Due to the additional workload at home, often referred to as the "second shift" (Hertz, 1990), mothers typically have less time for research than their peers. As a result, they may overcompensate by increasing their efficiency and extending their (unpaid) working hours (Kmec, 2013; Sallee et al., 2015). These attempts to 'catch up' increase stress levels and fatigue, eventually pushing mothers to make the inexorable choice between family and career to avoid burnout (Nicholls et al., 2022). Being the primary caregiver means that without adequate childcare support, mothers have to be continuously available to care for their children, at the expense of their career and personal wellbeing (Ruppanner et al., 2018). The COVID-19 pandemic exposed and magnified these longstanding inequities that unfairly disadvantage female scientists who are caregivers (Blowers et al., 2022). As schools and daycare providers closed during lockdowns, women struggled to balance their research and teaching roles with homeschooling, childcare, household chores and/or caring for an elderly or chronically ill family member, because their male partners were not doing their fair share of caregiving and domestic labour (Heo et al., 2022; Krukowski et al., 2022). Compounding this situation, an increase in administrative and teaching workloads caused by the shift from in-person to remote/hybrid teaching disproportionately impacted female academics, as they typically take on more teaching, mentoring, and administrative unremunerated labour than their male peers (Babcock et al., 2017; O'Meara et al., 2017; Collins et al., 2021). These pressures caused a well-reported decline in manuscript and grant application submissions for women, while men increased their scientific productivity (Andersen et al., 2020; Vincent-Lamarre et al., 2020; Muric et al., 2021; Squazzoni et al., 2021; Blowers et al., 2022). Mothers of colour absorbed the most extraordinary pandemic costs (Staniscuaski et al., 2021). As delaying publications and missing grant rounds lowers the chances of being awarded a research grant in subsequent funding opportunities (Jebsen et al., 2022), the pandemic has further damaged women's competitive advantage and widened the gender gap in STEMM academia.

Gender and caregiving in research funding policy

The COVID-19 pandemic showed that mothers are primary caregivers by default, not by choice. Women are forced by societal, cultural, and structural constraints (e.g., lack of affordable childcare providers) to be the primary caregiver and self-sacrifice for their family (Ruppanner et al., 2021; Docka-Filipek and Stone, 2021). Yet, this is only the tip of the iceberg. The maternal wall is complex and multifaceted, and its impact on women's career advancement is underestimated in STEMM academia. For example, there is a vast body of literature addressing gender bias and the 'glass ceiling' effect in academia, while much less research attention has been paid to the maternal wall (Williams, 2005; Jackson et al., 2014). The last two decades have seen an increasing demand for funding agencies to commission more research into improving efficiency and fairness in the grant selection process (Wallon et al., 2015; Recio-Saucedo et al., 2022). As evidence accumulates indicating that the maternal wall is a critical driver of the gender gap in STEMM, those research efforts should examine the experiences of mothers without discounting their intersectional identities, such as race/ethnicity (Bhopal and Henderson, 2019; McFarland et al., 2019; Kozlowski and Monroe-White, 2022), gender identity and sexual orientation (Cech and Waidzunas, 2021), and (dis)ability (Peterson, 2021). Equally, research funders should begin enacting policies to improve their practices and eliminate gender inequities and intersectional bias. We have developed an action plan for funding agencies that outlines specific, actionable strategies to close the gender gap in research funding and promote inclusion of caregivers, particularly mothers (Torres et al., 2023). Nearly all recommendations in this action plan are referenced to similar practices currently being implemented in agencies worldwide, showing that they are achievable. Below we discuss the major career obstacles facing mothers in STEMM and explain some of the strategies we propose in the action plan to remove those barriers (Torres et al., 2023) (see Table 1).

Maternity bias: accountability and action to create a veritable meritocratic system

Despite growing awareness, modest efforts have been made to tackle gender bias in the grant selection process and the efficacy of current interventions remains unclear. Moreover, to our knowledge, only one study has (indirectly) analysed maternity bias in research funding (Alvarez et al., 2019), finding that language related to family, gender, and age was predominantly used in women's evaluations in the Clinical Scientist Development Award scheme of the Doris Duke Foundation (United States). A subconscious awareness of maternity bias may cause women to avoid mentioning their maternity leaves and parental status in job and funding applications for fear of career penalties (Correll et al., 2007), thus creating an unfair disadvantage, as publication gaps are left unexplained. There has been a shift in these practices in recent years, however, as more funding agencies now allow applicants to add parental leave breaks to their CVs and explain productivity gaps. It is unclear though whether reviewers take these

TABLE 1 Systemic barriers hindering the career advancement of researchers with caregiving responsibilities and proposed actionable solutions for funding agencies to address these challenges.

Problem	Description	Solutions
Maternity bias	Maternity bias is the strongest form of gender bias. Mothers are less likely to be hired or promoted, receive fewer professional opportunities and lower salaries, and are perceived to be less competent as fathers or childless people. Unconscious bias/discrimination against women who have children (or who are pregnant) is widespread but largely unrecognised in the STEMM sector, including academia.	Clear actions to prevent gender/maternity bias in applicants' evaluations should be explicitly mentioned in reviewer guidelines using strong language (eg. citing examples of biases and relevant laws against maternity discrimination). Provide gender/maternity bias training with proven efficacy and enforce equal gender ratios in reviewer and award selection panels. Introduce gender quotas to correct potential gender biases in reviewer evaluations, increase women's representation and encourage women to apply. Collect and publish award data systematically and monitor application success rates, as well as amount of funding allocated, disaggregated by gender, race/ethnicity, (dis)ability, and parental/caregiving status. Immediately adapt policies to eliminate inequalities detected in these statistics.
Career gaps	Unequal parental leave policies strongly contribute to gender inequities in career progression, as they normalise gender roles and place expectations on mothers to the primary carer and take long career breaks for caregiving, while fathers are expected to be continuously working.	Provide equal paid parental leave to both parents (regardless of their gender) with a minimum duration of 16 weeks extendable beyond the duration of the award, and/or top up maternity and paternity leaves offered by the research institution to equalise them. Provide career re-entry scholarships, fellowships and research grants to students and researchers wanting to return to their academic career after a prolonged career break for caregiving (or other) reasons. Extend grant eligibility criteria and track-record assessment period by at least 18 months per birth for mothers, allow deferments to start dates, and provide grant extensions to researchers taking prolonged career breaks for caregiving (or medical) reasons. Provide flexible funding for hiring technicians and/or students to conduct field or lab work during pregnancy, parental, caregiving or medical leave (including for miscarriage or fertility treatment).
Gender roles	Societal pressure and internalised gender roles force women to be the primary caregiver, which means mothers have less time to apply for funding and to devote to research when childcare support is lacking. Funding agencies can enact equitable policies to level the playing field and to ensure academic mothers can fulfil their full potential despite these challenges.	Provide flexible childcare subsidies to help hiring childcare providers, including after-school clubs or nannies/babysitters for early school pickups, unexpected school or daycare closures, for when the children are sick, or when daycare centres (crèches) have no vacancies. Flexible and remote work, including part-time work, should be allowed by default in every grant and these policies should be clearly communicated to award recipients (including men) and to their host research institutions. Provide flexible supplements to conference travel grants to parents; these supplements should be doubled for single parents. Rolling or recurring deadlines should replace annual grant calls with a single deadline, and funding applications should be shortened and simplified to reduce the administrative burden and time necessary to prepare the application.
COVID-19 impact	The COVID-19 pandemic magnified longstanding inequities and systemic barriers that unfairly disadvantage academic mothers. Many were forced to reduce their work hours or quit their jobs for caregiving, resulting in a well-reported decline in manuscript and grant application submissions, while men increased their scientific productivity. Continued inaction will widen the research funding gender gap and reverse decades of progress to increase women's representation in STEMM academia	Extend grant eligibility criteria (including age limit requirements) by at least three years to mothers, single parents or caregivers affected by the pandemic. Provide funded extensions to current scholarships, fellowships and research grants to mothers, single parents and caregivers affected by the pandemic by at least two years, to allow the completion of projects and publications. Provide grants exclusive for female applicants and funding for career re-entry to caregivers who had to take a career break due to the pandemic.

career interruptions into consideration and what effect, if any, they produce on the applicant's evaluation.

Research funders need to be accountable, embrace transparency, and take meaningful action to address gender biases, including maternity bias. For example, specific actions to prevent gender and maternity bias in applicant evaluations should be explicitly mentioned in reviewer guidelines using clear and strong language [e.g., by citing specific examples of maternity biases and relevant laws against maternity

discrimination (Albiston and Correll, 2023)]. Funding agencies should also enforce equal gender ratios among external reviewers and award selection panels, and provide gender/maternity bias training with proven efficacy, such as gender bias habit-breaking interventions (Devine et al., 2017). Awareness and accountability are critical to break vicious circles of self-perpetuating bias and discrimination. Similar to sexual and psychological harassment (bullying), gender/maternity bias and discrimination are normalised and widespread in academia. Victims are discouraged from reporting incidents for fear of retaliations and career penalties, and because perpetrators are seldom made accountable. Funding agencies are no exception to this culture of impunity. Until very recently, only a handful of agencies collected gender disaggregated statistics for their award competitions, and even fewer monitored award success rates, which are fundamental to detect potential biases. To eliminate bias in the evaluation process, it is paramount that funders commit to monitoring and regularly publishing gender, race/ethnicity, (dis)ability, and parental/caregiving status data for grant success rates and funding amounts. Finally, gender quotas should be introduced to correct gender/maternity biases in the grant selection process and to increase women's representation (see below).

Funding agencies also play an important role in eradicating bias and promoting diversity and inclusion more broadly in the scientific community. Given that research institutions rely on public and external funding allocated in large part via competitive research grant schemes, funders have the power to influence policy and cultivate a culture of accountability at the institutional level through their grants' eligibility criteria (Wallon et al., 2015; Jebsen et al., 2022). The implications of such approaches are far-reaching, as national public agencies as well as private foundations follow the example of major funders such as the ERC in Europe or the National Science Foundation (NSF) in the United States, and are therefore likely to employ similar practices. Recent examples include several funding agencies joining Plan S, supported by the ERC, to mandate that all their funded research be published in open-access journals and, more recently, the ERC requires that applicant institutions have a Gender Equality Plan (GEP) in place as a grant eligibility criterion. Funding agencies could go further and demand that GEPs include specific caregiving policies and interventions to address gender/maternity bias, such as equal paid parental leave policies, default flexible/remote work, monitoring and publishing of gender identity, sexual orientation, race/ethnicity, (dis) ability, and parental/caregiving data for hiring and promotions, compulsory gender/maternity bias training for leaders and staff, nursing facilities, and childcare support. Funders can also reward applications from research institutions that demonstrate concrete policies aimed at increasing women's representation in senior academic positions, such as implementing gender quotas for hiring and promotion. Moreover, following the example of the Wellcome Trust (United Kingdom), funders should adopt a 'zero tolerance' policy and disqualify applications from researchers (including co-applicants) who received a disciplinary warning or active sanctions for an allegation of discrimination or harassment, and funding should be immediately removed from grant recipients convicted for such allegations during the period of the award. An anonymous online reporting system, similar to that established by the University of Cambridge (United Kingdom) after the #MeToo movement should be implemented to allow award recipients to report any type of misconduct, bias/discrimination or harassment perpetrated by their supervisor(s), colleague(s) or research institution(s). Complaints should be quickly investigated by an independent committee.

Career gaps: funding to support research continuity

In the vast majority of industrialised countries, with the exception of the United States, women are legally mandated to take several weeks to months of paid parental leave (and are entitled to additional optional months of paid and/or unpaid leave), while men need to take only a few days or no leave at all. These unequal policies not only contribute to gender inequities in income and workforce participation, but also perpetuate gender stereotypes and promote imbalanced family dynamics (Gottschall and Bird, 2003; Evertsson and Duvander, 2010; Rocha, 2020). Moreover, gendered parental leave policies often disregard same-sex couples and non-traditional families. While there is no doubt that women need time to recover from the physical and emotional toll of pregnancy and birth, men can and should share the postnatal caregiving burden and support the mother at this critical time. Extended maternity leave policies are not based on research data or biological constraints (International Labour Organization, 2014; European Institute for Gender Equality, 2019), they are a simple panacea devised by politicians to avoid dealing with the lack of public childcare infrastructure. There is no reason to justify unequal parental leave policies other than obsolete gender stereotypes that caregiving is primarily (or solely) a woman's responsibility. Funding agencies can play an important role in challenging these unfounded beliefs and promoting equal career-advancement opportunities to female and male academics by providing paid maternity and paternity (or secondary parent) leaves with a minimum of 16 weeks in award packages or topping up inadequate public and/or institutional parental leaves (Amberg et al., 2022).

In STEMM academia, career breaks for parental leave may affect scientific production in various ways: parents may miss grant calls, delay manuscript submissions, and lose precious time of data collection, which directly or indirectly impact on research funding success (Jebsen et al., 2020). Moreover, parental leave stigma magnifies gender and maternity biases (Bonache et al., 2020; Thébaud and Pedulla, 2022). As science is a fast-paced sector, even a career gap of a few months may have an important impact on career advancement. Until mandated equal maternity and paternity (or secondary parent) leave policies become the norm—a change that may take decades—funding agencies can implement measures to mitigate the gendered impact of current unequal parental leaves on researchers' careers. Although some agencies already provide extensions to grant eligibility criteria for each birth, the duration of these extensions may be insufficient, as productivity slowdowns may extend well beyond the duration of the parental leave (Williams, 2005). Moreover, these policies are often gender neutral, which may further increase gender inequalities (Antecol et al., 2018). Extensions to grant eligibility criteria (including age limit requirements) and to track-record period assessment should be calculated proportionately to the duration of the leave, with a minimum of 18 months per birth for mothers. To ensure research continuity, funders should also provide flexible funding by default for hiring technical support to conduct field or lab work during pregnancy, parental, caregiving or medical leave (including for miscarriage or fertility treatment). For example, the Swiss National Science Foundation (SNSF) offers a Flexibility Grant to support early career researchers during maternity leave that can be used for childcare expenses and/or to

employ a support scientist (Joyce et al., 2024). In addition, as paid maternity leave lengths are extremely variable (e.g., in the United States they can vary from zero to several weeks), this critical funding for research support should be provided for a minimum of 6 months to new mothers, to ensure they maintain scientific productivity during the physically taxing postnatal period (Aitken et al., 2015; Andres et al., 2016). Deferments to award start dates, grant extensions, and career re-entry funding should also be provided to researchers taking prolonged career breaks for caregiving (or medical) reasons.

Gender roles: flexibility and childcare support to increase retention

Mothers are not only the primary caregiver but are also the default parent when childcare support systems are inaccessible or simply fail, as the COVID-19 pandemic revealed (Calarco et al., 2021; CohenMiller and Izekenova, 2022). Shouldering the childcare burden alone puts mother scholars at disadvantage in the academic race, as they have less time (and mental bandwidth) to devote to research (Minello et al., 2020; Lantsoght et al., 2021; CohenMiller and Izekenova, 2022). Although these internalised gender roles are admittedly a societal issue, the scarcity of reliable and affordable childcare options is a structural problem, and funding agencies can enact equitable policies to level the playing field and ensure that scientist mothers can fulfil their full potential despite these challenges. Flexibility and childcare support are key (Chung and van der Horst, 2018; Marija Sikirić, 2021; Ferragina, 2020). Flexible childcare subsidies allow parents to employ childcare providers, including holiday/after-school clubs and nannies/babysitters for early school pickups, unexpected school closures, when the children are sick, or when daycare centres (crèches) have no vacancies. Flexible/remote work, including part-time work, should be allowed by default in every grant and these policies should be clearly communicated to host institutions and award recipients, including fathers, who are less likely to request using such policies. Another major problem facing parents, but especially mothers, is conference attendance. Female scientists are more likely than their male counterparts to decline opportunities to speak at and/or attend conferences due to family responsibilities, which has important implications for career progression (Schroeder et al., 2013). Single parents without a support network–a common scenario in academia due to the mobility requirements of many grants–do not even have the choice. Funders should provide flexible supplements to conference travel grants to parents, and such financial support should be doubled for single parents. Finally, rolling or recurring deadlines should replace annual grant calls with a single deadline (not rarely at an inconvenient time for parents, such as just before or during school holidays, for example), and funding applications should be simplified and shortened considerably to reduce the applicants' administrative burden and the time spent preparing the application (Jebsen et al., 2020). These practices would likely drive a significant increase in the number of female applicants, and particularly mothers. For example, in 2011 the Australian Centre for Health Services Innovation launched a research grant scheme with streamlined 1,200-word proposals that took approximately 7 days to prepare (Barnett et al., 2015), instead of the average four to 6 weeks required for a typical grant application (Herbert et al., 2013; von Hippel and von Hippel, 2015). Importantly, any provision to support parents, such as childcare subsidies and grant extensions, should be mentioned explicitly and clearly on the agency's website and should not require lengthy application procedures, which would further burden the applicants.

COVID-19: interventions to recover from pandemic impact

Despite many calls for change and the indisputable evidence showing that female researchers with caregiving responsibilities were gravely affected by the COVID-19 pandemic, funding agencies have remained mostly passive. A few agencies extended grant eligibility criteria and/or deadlines for grant applications during the pandemic, but these measures were gender neutral and largely insufficient. Continued inaction will widen the research funding gender gap and reverse decades of progress to increase women's representation in STEMM academia. Calls for support to academic mothers have been ignored because effective solutions require a financial commitment that indirectly affect researchers less impacted by the pandemic [to put it simply, white, able-bodied, heterosexual men (Jebsen et al., 2022)]. Nevertheless, governments can open their purses when there is enough pressure, as evidenced by the considerable boost in research funding prompted by the pandemic. Research funders should seize this unique opportunity to call on governments and stakeholders for support to finance COVID-19 long-term recovery and promote DEI (Cebula et al., 2020; Fulweiler et al., 2021; Jebsen et al., 2022). For example, in addition to extending grant eligibility criteria and track-record assessment period, funding agencies should provide funded extensions to scholarships, fellowships, and research grants (including salaries of students and/or technical staff hired on grant) to mothers, single parents, and caregivers affected by the pandemic. Moreover, as women and minoritised groups are more likely to be employed on precarious short-term contracts, and particularly early career researchers (Cebula et al., 2020), scientist mothers may have been forced to interrupt their career for caregiving during or following the COVID-19 pandemic. Funding agencies should therefore open research funding programs exclusive to female applicants, including career re-entry grants. Such equitable measures would help female researchers with caregiving responsibilities stay competitive and counteract the pandemic's negative impact on their productivity, thus ensuring future funding success and increasing retention.

The case for gender quotas

Gender quotas are highly controversial and widely unpopular in academia, including among women (Wallon et al., 2015). Funders fear that gender quotas in grant allocation will threaten meritocracy and jeopardise research excellence. Men fear they will unfairly lose the funding they deserve. And women fear being used as tokens and losing professional credibility. Ironically, these fears all stem from the same assumption: that gender quotas may give female applicants an unfair advantage over their male peers, which misses the point entirely–the aim of gender quotas is to remove the unfair advantage that men currently have over women. A recent study on gender quotas

in academia perfectly illustrates this widespread perception that support for women is unfair, while support for men–for example, gender quotas in academic fields where women outnumber men, such as social sciences–would be "natural and legitimate" (Zehnter and Kirchler, 2020). The authors found that negative verbal associations related to "unfair," "counterproductive" and "derogatory" were significantly associated with gender quotas that favoured women, and positive or neutral expressions such as "fair" and "beneficial" were associated with quotas to support men (Zehnter and Kirchler, 2020).

Meritocracy in research funding is a myth. Gender quotas correct unconscious biases and promote real meritocracy (Park, 2020). Mandated or voluntary gender quota policies have been widely explored in national parliaments and corporate boards with proven results in rapidly boosting women's representation in leadership positions (reviewed in Wallon et al., 2015). Moreover, there are other additional benefits. Gender quotas would encourage more women to apply for grants, which funding agencies recognise is a major obstacle to achieving gender balance in grant allocation (van der Lee and Ellemers, 2015; Burns et al., 2019). An increase in female applications would likely have a snowball effect and significantly (and rapidly) increase women's representation in STEMM leadership positions, as funding success improves the chances of promotion and hiring (Bloch et al., 2014; Heyard and Hottenrott, 2021; Hussinger and Carvalho, 2021; Jebsen et al., 2022). The advantages of gender quotas thus largely outweigh potential drawbacks, such as token effects. In addition, given the low success rate of most research funding schemes, there is a large pool of equally meritorious female and male applications that vastly outnumber the available grants (von Hippel and von Hippel, 2015). The risk of funding an undeserving female applicant is therefore negligible, and concerns that gender quotas threaten academic meritocratic systems are unfounded (van den Brink and Benschop, 2011). Ultimately, gender quotas should be viewed as a temporary measure until gender parity is achieved and gender bias in the grant selection process is eliminated through other complementary approaches (see above).

Gender quotas have already been adopted by a handful of funding agencies. For example, the Swedish Research Council (Swedish Research Council, 2022) and the Helmholtz Association in Germany (The Helmholtz Association of German Research Centers, 2013) request that women and men have equal award success rates in some of their funding schemes. Other agencies, such as the ERC and the National Research Council of Canada, have not set public official targets but have equalised their success rates between genders in recent years, suggesting they are applying implicit gender quotas. Equal success rate quotas ensure that the gender ratio among grant recipients reflects the number of applicants, thereby rectifying potential gender biases. However, this model of gender quotas is unlikely to increase women's representation (see Table 2) and thus perpetuates gender imbalances, especially if no other measures are taken to eliminate unconscious bias in the grant selection process. Among other initiatives, the National Health Medical Research Council (NHMRC) in Australia has recently introduced 50:50 gender quotas to some of its grants to ensure that an equal number of awards is allocated between men and women/non-binary people (NHMRC, 2022). This equitable policy is the culmination of a large consultation among researchers and independent organisations, following the publication of evidence of gender bias in the NHMRC funding system (Nogrady, 2022). The agency also aims to reduce gender disparities in application rates; while female and male researchers applied roughly at equal rates to early-career grants in recent years, only 20% of applicants to advance-career grants were women, a common trend observed among other funders (Nogrady, 2022). From the examples in other sectors, 50:50 gender quotas present many benefits, such as correcting gender bias, encouraging more women to apply, and rapidly increasing women's representation. A major downside of this gender quota model is that it cannot be applied to academic fields with very low representation of women (e.g., mathematics, physics, and economics), as there would be a considerable risk of funding without merit and the number of female applicants would be insufficient to achieve quota targets. Cascading gender quotas–where quota targets are based on the representation of women (i.e., percentage of female applicants) in the career level immediately below–may represent a viable compromise solution (see Table 2; Wallon et al., 2015). This is a more flexible model, applicable to any field, with quota targets set specifically for each funding agency and grant type–and with the important advantage of increasing women's representation, albeit not as rapidly as 50:50 quotas.

Funding agencies play a critical role in promoting gender equity and retaining women in STEMM academia

The COVID-19 pandemic exacerbated long-standing gender inequities in STEMM academia, with a devastating impact on the career of women scientists, especially those with caregiving responsibilities (Minello et al., 2020; Calarco et al., 2021; Staniscuaski et al., 2021; CohenMiller and Izekenova, 2022). Evidence is mounting suggesting that the gender gap in STEMM is essentially a parenthood gap (Cech and Blair-Loy, 2019; Morgan et al., 2021). Despite countless calls on STEMM leaders and policymakers to support mothers in STEMM and reform the funding system, research funders have not taken any meaningful action and continue to uphold a system that marginalises mothers and other caregivers. Why? One explanation is a widespread culture of interventions to 'fix women', rather than fixing the system, because it is easier to blame women than recognising and repairing systemic flaws (National Academies of Sciences, Engineering, and Medicine, 2020; Catalyze Tech Working Group, 2021; National Academies of Sciences, Engineering, and Medicine, 2024). Funders and STEMM leaders frequently dismiss the experiences of women, particularly mothers, and consciously or unconsciously reframe the leadership gender gap as an unavoidable consequence of women's perceived (in)competence and personal choices. These gender stereotypes are founded on deeply ingrained beliefs that women cannot be as competent or as ambitious as men because they are distracted by motherhood (Correll et al., 2007). A shift away from the 'fixing women" mindset is crucial to retain women in the STEMM sector and to build a truly fair and meritocratic funding system. Funding agencies should stop asking: what should women be doing to achieve funding success? And instead need to examine why the system unfairly favours men and discourages women from applying for grants. Statistically, most women applying for mid- and advanced-career research grants are mothers (Morgan et al., 2021). Funders must take immediate action to remove the systemic barriers that stymie women's success in research funding, while

TABLE 2 Overview of gender quota models highlighting their advantages, disadvantages, and examples of funding agencies and research institutions that have implemented them.

Model	Description	Advantages/disadvantages	Examples
Equal success rate quotas	Men and women have equal award success rates, i.e., the ratio between applicants and awardees is the same for men and women.	✓ Corrects gender bias ✓ Applicant pool is fairly represented ✓ Negligeable risk of funding without merit ✓ Applicable to any field ✗ Does not eliminate gender bias ✗ Unlikely to encourage more women to apply ✗ Does not increase women's representation ✗ Perpetuates gender gap	The *Swedish Research Council* committed to "ensuring that men and women have equal success rates in grant applications" in its Gender Equality Plan (GEP, 2022). https://embassy.science/wiki/Resource:B24c135d-46b8-402a-a06b-5ef8838695c1 The *European research Council* has recently achieved gender equality in success rates and has committed to monitoring and maintaining these rates (GEP 2021-2027). https://erc.europa.eu/news-events/magazine/erc-adopts-new-gender-equality-plan The *National Research Council of Canada* aims for employment equity targets by 2024 to "build a diverse and representative workforce" including women, Indigenous peoples, visible minorities, and people with disabilities. https://nrc.canada.ca/index.php/en/corporate/planning-reporting/equity-diversity-inclusion
50:50 quotas	An equal number of awards is allocated between men and women.	✓ Corrects gender bias ✓ Increases women's representation rapidly ✓ Encourages women to apply ✗ Does not eliminate gender bias ✗ Not applicable in fields with very low representation of women ✗ Risk of funding without merit for grants with high success rates	All Austrian federal institutions and organisations, including universities, are mandated to preferentially select a female candidate over an equally qualified male candidate for any position until reaching a 50:50 ratio of men and women holding equivalent positions. The *National Health and Medical Research Council* in Australia has committed to allocating an equal number of grants between men and women/non-binary people for its advanced-career Leadership grants (L1, L2 and L3). https://www.nhmrc.gov.au/about-us/news-centre/working-towards-gender-equity-investigator-grants
Cascading quotas	Quota targets are set based on the percentage of women in the career level immediately below. E.g., if there are 40% of female applicants for mid-career grants, quota targets for advanced-career grants are set at 40%, even if women represent only 30% of applicants.	✓ Corrects gender bias ✓ Applicable to any field ✓ Quota targets set specifically for each agency and grant type ✓ Encourages women to apply ✓ Increases women's representation (albeit gradually) ✗ Does not eliminate gender bias ✗ Unlikely to close gender gap ✗ Increases women's representation more slowly than 50:50 quotas	The *Swiss National Science Foundation* uses the following gender quotas for hiring faculty: • Research Council: at least 40% women and men, 20% flexible • Other evaluation bodies: quota adapted to the field. Share of women must be 20% higher than share of professors in the field. The agency plans to do similar actions for funding, but it is not officially implemented yet. https://www.snf.ch/en/kjCKYzJgvuNWbsf2/news/news-210205-quotas-to-promote-gender-equality-in-research The *Université Libre de Bruxelles* also follows cascading quotas for hiring faculty. https://www.ulb.be/fr/diversites/egalite-des-genres

simultaneously using their influence to promote equity and inclusion of caregivers more broadly in the scientific community. DEI programs and initiatives should be expanded to caregivers, with an emphasis on mothers, without disregarding intersectionality issues, as mothers may also experience marginalisation from other identities, including race/ethnicity, gender identity, sexual orientation, (dis)ability or socio-economic status (Wang and Degol, 2016).

Best practices for research institutions

While funding agencies are vital for promoting caregiver inclusion and increasing the retention of women in STEMM academia, coordinated efforts among all stakeholders—research institutions, science societies, and governments—are essential. Institutional leaders play a critical role in enacting and enforcing policies to promote DEI and harmonising these practices across departments, as top-down approaches are often more effective in driving systemic change (Jebsen et al., 2022). Leaders are also instrumental for ensuring systematic and rigorous data collection of caregiver policy uptake and efficacy, which is essential to improve policies and maximise the impact of DEI efforts to promote an equitable and inclusive workplace. Critically, leaders need to set the example, promoting accountability and actively driving cultural change in their institution (National Academies of Sciences, Engineering, and Medicine, 2024). Moving away from workplace cultures based on "ideal worker" norms and expectations is crucial to encourage caregivers to use available policies, thus eliminating gender inequalities in caregiving policy uptake (Sallee, 2012; Ecklund et al., 2017), which create unfair disadvantages for women and perpetuate the gender gap in STEMM (Cech and Blair-Loy, 2019). Additionally, DEI initiatives may fall short by failing to consider individual needs and intersectional identities (Castañeda et al., 2015; York University, 2020). For example, caring for an elderly adult is more prevalent in Hispanic, Asian and Black communities, including caring for extended family members or friends (McCann et al., 2000; Miyawaki, 2016). Leaders must ensure that all individuals and communities are heard

and adequately represented when designing tailored and effective caregiving policies.

To foster a more inclusive environment for caregivers, particularly mothers, research institutions can adopt several best practices (Fulweiler et al., 2021; Sebastián-González et al., 2023; Joyce et al., 2024), acknowledging the diverse experiences of individuals and the intersection of their unique identities, including race/ethnicity, gender identity, sexual orientation, (dis)ability and socio-economic class. First and foremost, as discussed above, research institutions should provide equal paid parental leave to both mothers and fathers (or the secondary parent), and/or top up leave benefits to all employees, including students and research staff on fixed-term contracts. In addition, a range of childcare support options should be offered to students and research staff with parental responsibilities. For example, *in-situ* childcare facilities can provide convenient and reliable care for young children and facilitate breastfeeding, thus allowing mothers to return to work sooner and continue nursing their infants (Navarro-Rosenblatt and Garmendia, 2018). In addition, providing emergency childcare and flexible childcare subsidies can help parents manage unexpected situations and avoid absenteeism, reducing stress and ensuring research continuity. Research institutions should follow the example of the University of Lausanne (Switzerland) which provides four on-campus daycares for children from 2 months to 4.5 years old, 12 weeks of holiday activities/camps for children during school holidays, emergency childcare for sick children, and breastfeeding facilities and changing tables in every building (Joyce et al., 2024). Flexible and remote working arrangements should be allowed and normalised to respect people's personal lives and accommodate the schedules of caregivers. All meetings, seminars and networking events should always be hydrid and scheduled during standard working hours to ensure participation of caregivers, remote workers and researchers on parental or medical leave.

The use of parental leave and flexibility policies, such as flexitime and part-time work, can result in career penalties including lower salaries, poor evaluations, fewer promotions, and workplace marginalisation, as they reinforce flexibility bias and stigmas associated with perceived reduced work commitment and productivity (reviewed in Williams et al., 2013). Mothers are disproportionately affected due to the stark imbalance between paternity and maternity leave durations and because they are more likely to use these policies (Williams et al., 2013; Thébaud and Pedulla, 2022). Despite a lack of research on the efficacy of "keep in touch" (KIT) policies, providing optional, paid KIT days during parental leave may help researchers stay connected with colleagues, remain informed about scientific advances, and ensure their participation in publications and research projects, thereby facilitating a smoother transition back to work after parental leave and reducing workplace marginalisation. In addition to KIT days, research institutions can help mitigate the negative impact of parental leave on productivity by hiring a "roving researcher" to provide technical support and ensure that research projects continue in the primary researcher's absence. Notable examples of these policies include the Medical Research Council's Laboratory of Medical Sciences at Imperial College London (UK) and the Babraham Institute (UK), which have successfully implemented "roving researchers" and KIT days to support researchers on parental leave (Coombs, 2024).

Gender and maternity biases significantly affect hiring and promotion processes and limit career development opportunities for mothers in STEMM fields, and these challenges are further compounded by intersectional identities (Bhopal and Henderson, 2019; McFarland et al., 2019; Cech and Waidzunas, 2021; Peterson, 2021; Kozlowski and Monroe-White, 2022). To effectively address these issues, it is crucial to take actionable steps to eliminate the prevalent culture of impunity, nepotism, and normalisation of discrimination and harassment in academic institutions (Swann, 2022; Ciucurel, 2023; Corbett et al., 2024). For example, mandatory training for leaders and research staff (including students) on unconscious biases and anti-discrimination legislations, including for pregnancy and maternity bias, should be provided. To ensure fairness and eliminate unconscious biases in hiring and promotions, research institutions should implement a standardised selection process with clear evaluation criteria, structured interviews, and guidelines for selection committee members that include information on anti-discrimination legislation (Albiston and Correll, 2023; Joyce et al., 2024). Moreover, regularly monitoring and publishing data on salaries, promotions, and hiring–disaggregated by gender identity, parental or caregiving status, race/ethnicity, sexual orientation, and (dis)ability–is essential for promoting transparency, helping institutions identify areas for improvement, and ensuring accountability for advancing gender and caregiving equity. Finally, research institutions should establish an anonymous reporting system with an external investigation committee to handle bias and discrimination complaints, as discussed above.

By adopting these best practices, STEMM research institutions can create a more inclusive environment that supports caregivers, and especially mothers. These measures not only promote equity but also enhance the retention and success of talented individuals who might otherwise face significant barriers to career advancement.

Conclusion

Achieving equity in the academic enterprise requires institutional commitment, accountability measures, data collection and monitoring, and the courage to recognise that our current systems are not meritocratic. Acknowledging this bitter truth raises a moral obligation to remove inequities and build a fairer system for everyone. Addressing the STEMM leaky pipeline and, consequently, increasing women's representation in positions of power–particularly women caregivers–will help disrupt cycles of nepotism and accelerate progress towards a more inclusive STEMM sector. We have created an action plan with strategies to guide funding agencies in this endeavour. Change is possible when there is accountability and the will to take action. Promoting gender equality and diversity is still not a top priority in our leaders' agendas, but it should be. A more representative and inclusive funding system will make for better science, fostering discoveries and driving innovation; society as a whole will benefit. And ultimately, the values of fairness, honesty and integrity should be providing the ethos for systemic change.

Author contributions

IT: Conceptualization, Formal analysis, Project administration, Supervision, Writing – original draft, Writing – review & editing. R-NC: Writing – review & editing. AH: Writing – review & editing. ML: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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