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Academic performance of ecologists is gender-biased: effect of caregiving responsibilities and the working environment

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ABSTRACT

As the scientific environment is hierarchical and meritocratic, greater dedication will lead to higher performance. Consequently, scientists with caregiving responsibilities will suffer downfalls in performance. Caregivers are mainly women so their career is more affected than their male counterparts'. Based on a self-perception survey among Argentinean ecologists, we studied the distribution of caregiving responsibilities, uninterrupted time dedicated to work, career paths, perception of researchers' own work and that of others in relation to gender, and reciprocal effect between family and work. We found that a larger percentage of women carry caregiving duties, dedicate less uninterrupted time to work, and more to non-work-related tasks, especially when working from home. We found no effect of caregiving on age at promotion, although women tend to start earlier stages of their careers younger than men, while the trend reverts in later

categories. Women tend to value their own work more poorly than men, and both female and male researchers tend to choose male over female referents and advisers, especially among older generations. The interaction between family and work is perceived negatively by women in early career stages. In general, women and men felt supported by their advisers with respect to family-related issues. Caregiving duties must be considered when evaluating a researcher's performance, especially for women. Public policies must help relieve women from heavy caregiving tasks and facilitate leaving their home space to detach from not-work-related tasks. Greater peer recognition of women's research should increase their participation as advisers and referents, as well as their own perception of their work and those of other women. We must actively propose policies that will turn academy into a fairer and more equitable working environment for women.

INTRODUCTION

Doing science involves working in an environment with high demands, often beyond the regular eight-hour work shift, including weekends and holidays, traversing stressful deadlines and being continuously evaluated by peers and bosses of one's². Moreover, the scientific environment is hierarchical and meritocratic so greater dedication will lead to higher performance and achievement of higher ranks. Consequently, a scientist with other responsibilities, namely caregiving, will most probably suffer downfalls in performance³. There is increasing evidence that the majority of caregivers are women⁴, which often results in lower productivity of female scientists in comparison to that of their male counterparts³, and thus, women may feel a stronger negative interaction between having a family and a successful career than men⁵. This may contribute to women deserting their career paths early and resulting in shorter career paths than those of their male colleagues^{6,7}, which has been termed a "leaky academic pipeline"^{8,9}.

The proportion of women in science has gradually increased since the 50's to date. Paradoxically, gender gaps in productivity and impact on differential achievement in scientists' careers have increased regularly since the 70's for all disciplines and in most countries⁷. Multiple dimensions of gender inequities¹⁰ are globally well-known, accounting for disparities on number of researchers, positions, number of citations, funding, recognition, promotions to higher categories, and salary, among other aspects¹¹⁻¹⁴. Latin American countries often have a strong presence of women in their scientific systems, yet the gender gap persists¹⁵⁻¹⁸. Argentina has often been cited as exemplary in gender equity among its researchers¹³, with 54% women in 2019 in Argentina's main public science institution, the National Council for Scientific and Technical Research (hereafter CONICET for its acronym in Spanish), which sets it much higher than the world average of 28% women as research and technological development employees (<https://cifras.conicet.gov.ar/publica/detalle-tags/3>). Yet, women seem to face barriers as they advance in their scientific careers, which prevent them from reaching the higher ranks¹⁹. The high percentage of women in the Argentinean public scientific system mentioned above is mainly driven by gender distribution among Assistant Researchers,

the lowest and most populous of five categories of researchers, where women represent 61%. Yet the proportion of women decreases to 25% among Superior Researchers, the fifth and highest category in the Institution (<https://cifras.conicet.gov.ar/publica/>). Detailed studies on specific cohorts of researchers between 1994 and 2002 also show that, although women tended to increase in numbers in the later years in the upper categories, men promoted more, or at least faster²⁰. This pattern recovers the classical vertical segregation shown in most scientific institutions, where the gender gap is evident as the above-mentioned pipeline leak^{3,7}.

If we have a demonstrably gender-related problem that systematically affects the careers of women in science, we are facing an issue of public interest, and a serious need to understand the mechanisms causing it. We must ask “how” and “why”. How is the burden of caregiving tasks for women compared to that taken by their male counterparts? Are women less productive and why? Are they working less hours or less productively? Are they working in a somewhat hostile environment (i.e. an environment in which they are not recognized), and, if so, how does this prevent them from achieving their full potential?

Female scientists receive less recognition than their male counterparts; for example, there is a much lower representation in certain academies of sciences²¹, high-achieving male scientists train less women²² and women are less likely than men to occupy leadership roles¹⁰. Perhaps an unwelcoming work environment affects performance by women, as perception of our own academic performance may depend on the surrounding environment. Understanding how women value their own performance, and if self-esteem issues, likely resulting from the lack of recognition, affect their performance in science^{8,23}, will help visualize and take action on something that women have been pointing out for several years: the working environment is more hostile for women than for men. On the flip side, how much we value the work of other colleagues, especially if they are female, will reflect our vision of women in the sciences. Although gender differences in science are evident worldwide^{7,13}, and may be affected by our perception and evaluation of our own work and that of others^{8,23,24}, it is key to understand this problem in local cultures.

To focus on a somehow homogeneous universe of sampling, we chose to focus on Ecology. More specifically, we chose to work on Argentinean ecologists, as they are representative of Latin America, and regions where women are increasing their participation in the sciences, but still face inequities. Work in this field entails long lab hours and field trips away from home, which will be especially demanding when combined with non-work-related responsibilities. If women indeed carry the heaviest part of caregiving responsibilities, female ecologists will be at a serious disadvantage in comparison to men, due to the difficulties of being absent from home for long periods of time. Moreover, there is evidence of blatant inequities when it comes to authorship in leadership positions, percentage of representation in tenured jobs, and the amount of funding received between female and male ecologists¹¹. We believe that our results could be extrapolated to other disciplines with a heavy burden of field work.

The life experience of the protagonists who are both stuck in a long-established system, and are themselves a working part of it, is a first class source of data to understand the possible processes underlying well-known gender inequity. We collected data through a self-perception survey among Argentinean ecologists, to answer the following questions: 1. How are caregiving responsibilities distributed between female and male ecologists? 2. Are ecologist's performance and dedication to work affected by caregiving responsibilities, gender, or both? 3. Are career paths of women scientists different from male scientists'? 4. How do researchers value their own work performance, and that of others (i.e., choice of referents and Ph.D. adviser), and how is that related to gender? 5. How do researchers perceive the interaction between having a family and a successful career? 6. Do PhD students feel supported by their advisors when dealing with family-related issues? And how is this perception related to student and advisor genders, and caregiving responsibilities? By addressing these questions, we can contribute to the development of effective public policies to counteract present-day inequities. Science institutions must ensure the same opportunities for women and men as they develop a scientific career.

RESULTS

We obtained 437 responses from Argentinean ecologists, from different institutions throughout the country, mostly public, and predominantly from CONICET. Among participants, 282 were women (64.5%), 152 were men (35.5%), and 3 respondents (0.6%) identified themselves as "Other gender". Therefore, we restricted statistical analyses and conclusions to women and men. The total number of respondents that belonged to CONICET was 346, of which 234 (68%) were women and 112 (32%) were men, including doctoral and postdoctoral fellows, and researchers in all categories. This approximated the gender proportions observed in the population of CONICET researchers (<https://cifras.conicet.gov.ar/publica/detalle-tags/3>).

Regarding our first question, on the distribution of caregiving responsibilities between genders, we found that, among researchers that report having caregiving responsibilities (124 women and 62 men), a larger percentage of women (55%) than of men (5%) reported carrying more than half of caregiving duties. A smaller percentage of women (2%) than men (27%) reported carrying less than half of caregiving duties (X-squared = 58.705, d.f. = 2, $p < 0.001$) (Figure 1).

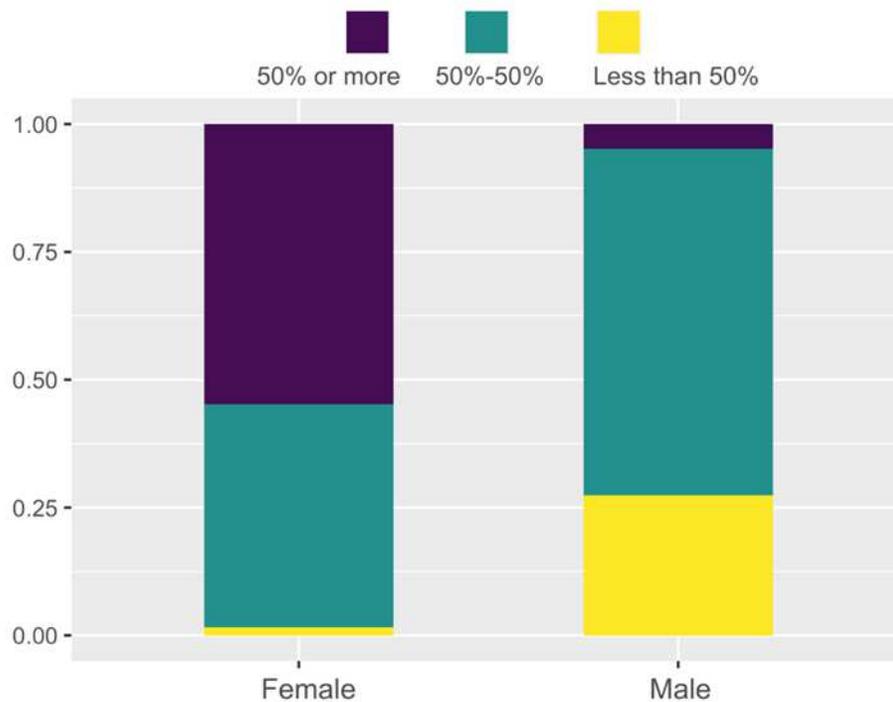


Figure 1: Percentage of female and male survey respondents with caregiving responsibilities among Argentinean ecologists that report to take charge of 50% or more of the responsibilities of caregiving (purple), share those responsibilities evenly with their partner (turquoise), or take charge of less than 50% of their corresponding responsibilities (yellow). Clearly, female ecologists in Argentina take charge of over 50% of caregiving responsibilities much more frequently than their male counterparts. Conversely, men respond much more frequently that they take charge of less than 50% of the shared responsibility. The choice of 50-50 share of responsibilities is evenly distributed between female and male respondents.

For our second question, we used uninterrupted working hours as a proxy to dedication to work. Researchers without caregiving duties, regardless of gender, reported working an average of 6.2 uninterrupted hours. Researchers that had caregiving duties but took charge of less than 50% of the burden reported working, on average, 5.7 uninterrupted hours, while those that take charge of 50% or more of caregiving duties work, uninterrupted, the least number of hours, 5.25 h ($F = 5.7$, $d.f. = 2$, $p = 0.004$). We also found that there was no difference in the mean number of uninterrupted hours worked by men (mean = 5.77 h, $n = 108$) and women (mean = 5.68 h, $n = 234$) with caregiving responsibilities ($t = -0.29$, $d.f. = 340$, $p = 0.77$) (Figure 2). When considering both gender and levels of caregiving duties, women and men without caregiving duties reported the longest period of uninterrupted work time, which was significantly greater than reported by men and women that take on half or more than half of their shared caregiving responsibilities ($F = 2.31$, $d.f. = 5$, $p = 0.044$). Women and men that take charge

of less than half of their shared responsibilities show an intermediate position and do not differ significantly between them and from the other combinations of gender and caregiving responsibilities. While doing home office, there is a significant difference in the time that researchers dedicate to non-work-related issues. Overall, researchers with higher caregiving duties tend to occupy more than one hour of work time in non-work-related issues, while researchers with less, or no caregiving duties tend to occupy less than one hour to no time at all, more often than expected by chance (Chi-squared = 18.04, d.f. = 4, $p = 0.0012$) (Table 1). While working from the office, there is no statistical difference in the time invested in non-work related tasks among researchers with different caregiving duties (Chi-squared = 7.52, d.f. = 4, $p = 0.111$) (Table 2), nor between men and women (Chi-squared = 11.68, d.f. = 10, $p = 0.31$). When working from home, however, women with a heavy load of caregiving duties dedicate more time to non-work related demands during work hours than any other gender-caregiving category (Chi squared = 24.7, d.f. = 8, $p = 0.0017$). Women with no caregiving responsibilities at all reported dedicating the lowest amount of time to non-work-related demands (Table 3).

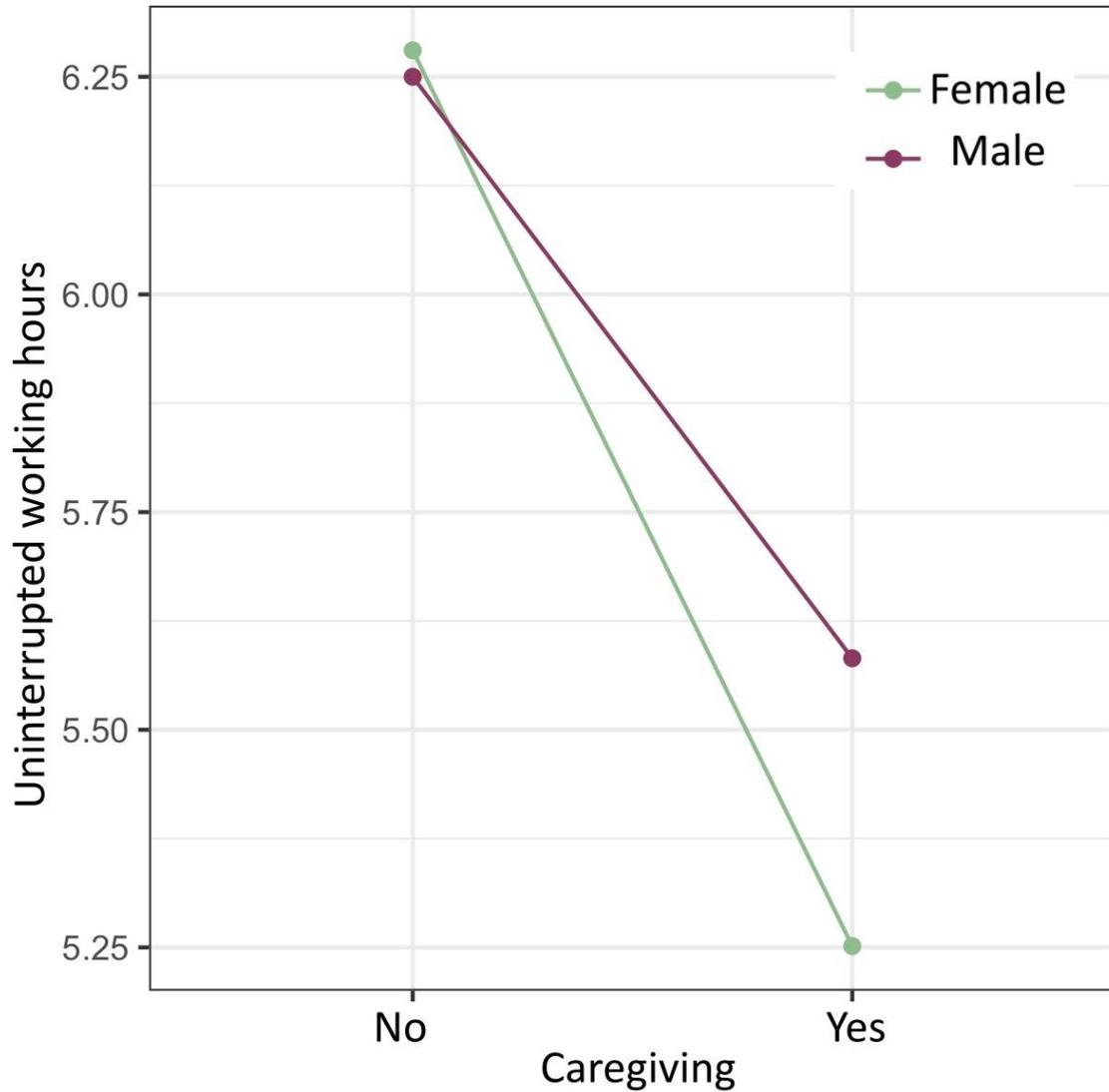


Figure 2: Average number of uninterrupted hours worked by female (green) and male (purple) Argentinean ecologists with (“Yes”) and without (“No”) caregiving responsibilities. Caregiving responsibilities are associated with less uninterrupted hours of work for male and female researchers.

Table 1. Number of lost hours during home office as a function of caregiving responsibilities. Deviations from what is expected under independence. In columns: Caretaking responsibilities.

Work hours lost at home	Caretaking responsibilities		
	50% or more	Less than 50%	None
One hour or more	10.85	0.88	-11.73
Less than one hour	-13.01	-0.61	13.62
Nothing	2.15	-0.27	-1.89

Pearson's chi-squared=18.04; df=4; p-value=0.0012

Table 2. Number of lost hours while working from the office as a function of caregiving responsibilities. Deviations from what is expected under independence. In columns: Caretaking responsibilities.

Work hours lost at office	Caregiving responsibilities		
	50% or more	Less than 50%	None
One hour or more	4.62	3.28	-7.9
Less than one hour	-3.16	0	3.16
Nothing	-1.46	-3.28	4.74

Pearson's chi-squared=7.52; df=4; p-value=0.1108

Table 3. Number of lost hours during home office, as a function of gender and caregiving responsibilities. Deviations from what is expected under independence. In columns: Gender and caregiving responsibilities.

Work hours lost at office	Gender and caregiving responsibilities				
	Women 50% or more	Women None	Men 50% or more	Men Less than 50%	Men None
One hour or more	7.63	-8.4	3.23	0.88	-3.33
Less than one hour	-7.54	10.4	-5.47	-0.61	3.22
Nothing					

Pearson's chi-squared=24.7; df=8; p-value=0.0017

When considering number of publications as first authors in peer-reviewed journals as a proxy of performance, we found that for PhD and Postdoctoral Fellows (PPF), there is a relationship between the number of publications and the burden of caregiving duties ($F = 8.04$, $d.f. = 2$, $p = 0.0005$), although not completely as expected. Fellows with the highest burden show less publications than those with a lower burden (mean = 2.93 vs. 5.14, respectively). Fellows with no caregiving duties at all show the lowest number of publications (mean = 1.63) (Table 4). For Early Career (ECR) and Senior Researchers (SR),

we found no relationship between caregiving duties and the number of publications (ECR: $F = 0.78$, d.f. = 2, $p = 0.4615$, Table 5; SR: $F = 1.24$, d.f. = 2, $p = 0.2971$, Table 6). When we consider gender, there are significant differences in the mean number of publications between women (1.71) and men (3.4) only for PPF ($t = -2.2$, d.f. = 33, $p = 0.04$). Women and men in the ECR and SR categories, show a similar trend to PPF although not significant (ECR: mean = 8.67 total papers for women, 9.95 for men, $t = -1.01$, d.f. = 58, $p = 0.32$; SR: mean = 23.17 for women, 33.52 for men, $t = -1.53$, d.f. = 44, $p = 0.13$). When we take into account the different levels of caregiving duties and gender, we found an effect for PhD and Postdoctoral Fellows ($F = 5.18$, d.f. = 4, $p = 0.0007$). Men with less than 50% of caregiving responsibilities published the most (5.14), followed closely by men with half of the responsibilities (4.40), and by women with 50% or more of caregiving responsibilities (2.61). The lowest numbers of papers are reported by men and women without caregiving duties (2.44 and 1.44, respectively). We do not find such differences for researchers (ECR: $F = 0.79$, d.f. = 5, $p = 0.556$; SR: $F = 1.27$, d.f. = 4, $p = 0.296$).

Table 4. LSD Fisher tests for numbers of published papers as a function of caregiving responsibilities (CR) for PhD and Postdoctoral Fellows ($\alpha=0.05$, $LSD=1.79487$, error: 6.5261, df: 127). Means with a common letter are not significantly different ($p > 0.05$). LSD: least significant difference; SE: standard error.

CR	Means	n	SE	Groups
None	1.63	95	0.26	A
50% or more	2.93	28	0.48	B
Less than 50%	5.14	7	0.97	C

$F=8.04$; $df=2$; $p\text{-value}=0.0005$

Table 5. LSD Fisher tests for numbers of published papers as a function of caregiving responsibilities (CR) for Early Career Researchers ($\alpha=0.05$, $LSD=4.12187$, error: 36.0261, df: 143). Means with a common letter are not significantly different ($p > 0.05$). LSD: least significant difference; SE: standard error.

CR	Means	n	SE	Groups
None	6.29	7	2.27	A
50% or more	9.11	35	1.01	A
Less than 50%	9.2	104	0.59	A

$F=0.78$; $df=2$; $p\text{-value}=0.4615$

Table 6. LSD Fisher tests for numbers of published papers as a function of caregiving responsibilities (CR) for Senior researchers ($\alpha=0.05$, $LSD=22.88491$, error: 679.9750, df: 49). Means with a common letter are not significantly different ($p > 0.05$). LSD: least significant difference; SE: standard error.

CR	Means	n	SE	Groups
None	23.31	26	5.11	A
50% or more	32	5	11.66	A
Less than 50%	35.19	21	5.69	A

F=1.24; df=2; p-value=0.2971

For our third question, we found that the age at which researchers start at different categories in CONICET is not a function of the level of caregiving responsibilities (Figure 3A). We did not analyze these data statistically as the data show no pattern in relation to level of caregiving responsibility. However, it is associated with gender. Women start as PPF younger than men do ($H = 4.562$, $df = 1$, $p = 0.033$) while we found no significant differences for the other categories (ECR: $H = 0.166$, $df = 1$, $p = 0.684$; SR: $H = 0.00007$, $df = 1$, $p = 0.993$). Statistical analyses were performed using the three categories described earlier (PPF, ECR and SR) to have enough data in each category and to avoid increasing the number of pairwise comparisons. However, we graphed all CONICET categories to visualize the pattern more clearly (Figure 3B), and we see that for the first three categories of CONICET, women tend to start earlier than men, and the trend seems to revert in later categories.

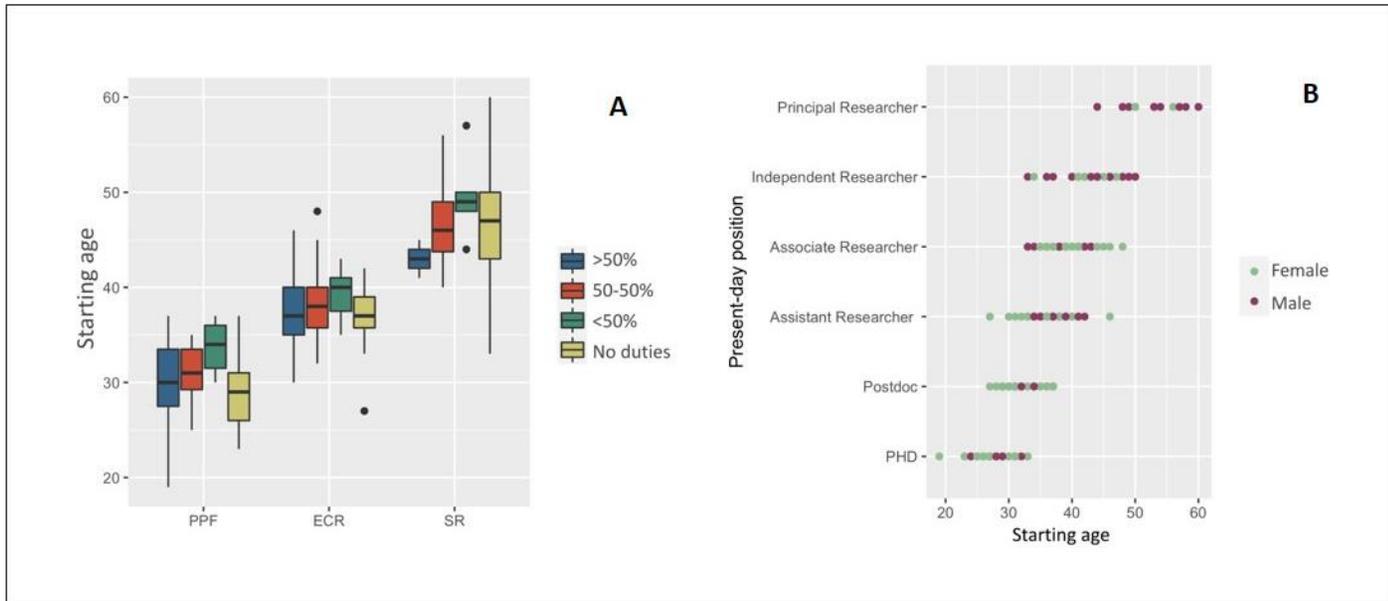


Figure 3: Age at which Argentinean ecologists entered the CONICET category that they hold at present, according to level of caregiving responsibility (A) or gender (B). A. PPF: PhD and Postdoctoral Fellows, ECR: Early Career Researchers, SR: Senior Researchers. Levels of caregiving responsibilities are as follows: researchers that take care of 50% or more of the caregiving responsibilities in relation to their partners (blue); those who equitably share caregiving responsibilities (red); those who take responsibility for less than 50% of their corresponding responsibilities (green), and those with no caregiving duties (yellow). B. Each dot represents one person that answered the survey. In green are women respondents, in purple male respondents.

Results related to our fourth question, regarding self-perception of academic performance, show that 70% of respondents categorized themselves as average in comparison with colleagues at the same stage of their career. The number of publications explained self-perception of academic performance for male and female researchers (Table 7). Given the same number of papers, the probability that a woman researcher classified herself as below average, or average, was higher than that for men (Figure 4A and B, Table 7). Instead, the probability that a male researcher classified himself above average was higher than that for women (Figure 4C). The model shows that these probabilities become similar between women and men with a very high number of papers published (Figure 4).

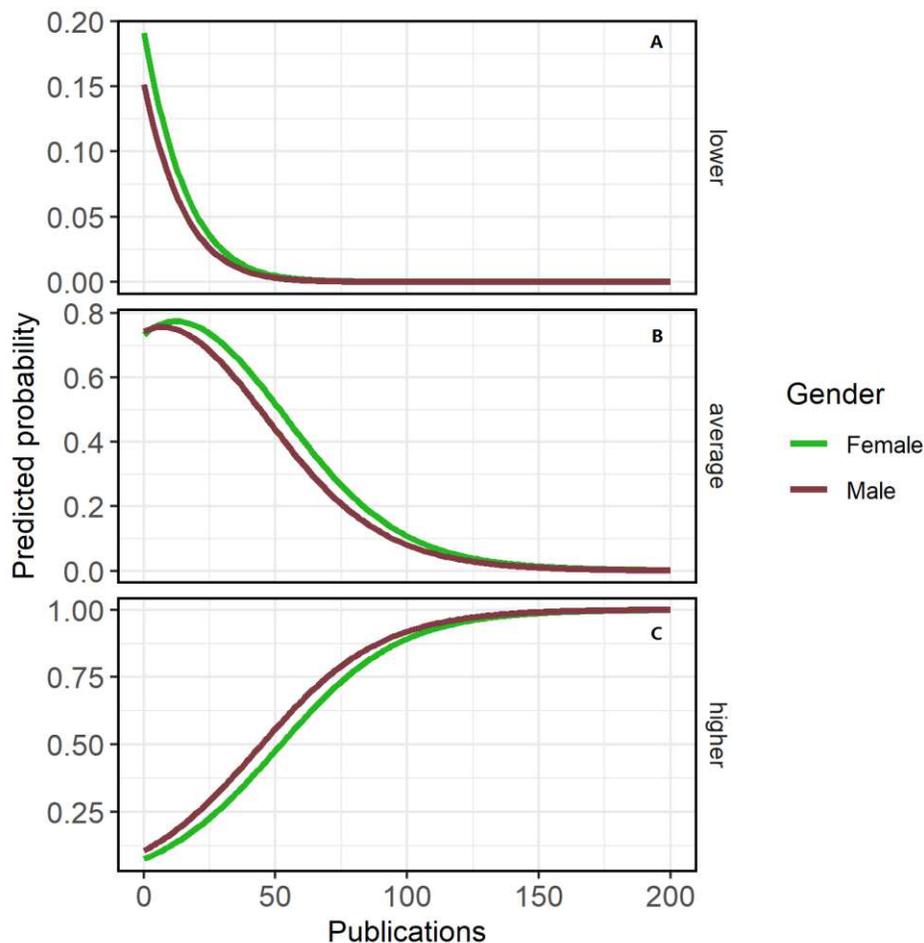


Figure 4: Results of a multinomial test showing that the probability that a female researcher (green lines) will classify herself as below average (A) or average (B) based on academic performance, in relation to fellow researchers, is higher than for males (purple), given the same number of publications. Conversely, the probability that a woman will classify herself as higher than average (C) is lower than that for men.

Table 7. Multinomial logistic regression model results regarding self-perception of academic performance expressed as odd ratios (CI 95%). N = 357. Base category is “below average” self-perception of academic performance. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Predictor	Category “as average”	Category “higher than average”
N publications	1.06 * (1.0-1.1)	1.11***(1.04-1.1)
Female	3.83*** (2.3-6.1)	0.39*** (0.2-0.74)
Male	4.9***(2.2-10.8)	0.69 (0.26-1.8)

When we analyzed the choice of academic referents in their field of studies, 1202 respondents mentioned more men (81%) than women (19%) (Chi-squared = 37.122, d.f. = 1, $p = < 0.0001$). Of the referents chosen by female respondents (807), 24% were women, and this percentage was even lower for male respondents (8%) (Figure 5A). Similarly, male advisers were a lot more common than female advisers (Figure 5B). When data were partitioned in different categories of researchers, the largest proportion of female advisers was found among current Doctoral and Postdoctoral Fellows, and the lowest among late career researchers (Chi-squared = 11.729, d.f. = 2, $p = 0.003$) (Figure 5B). The choice of female or male adviser is independent of advisee gender (PPF: Chi-squared = 0, d.f. = 1, $p = 1$; ECR: Chi-squared = 1.314, d.f. = 1, $p = 0.252$; SR: Chi-squared = 0, d.f. = 1, $p = 1$; Figure 5B).

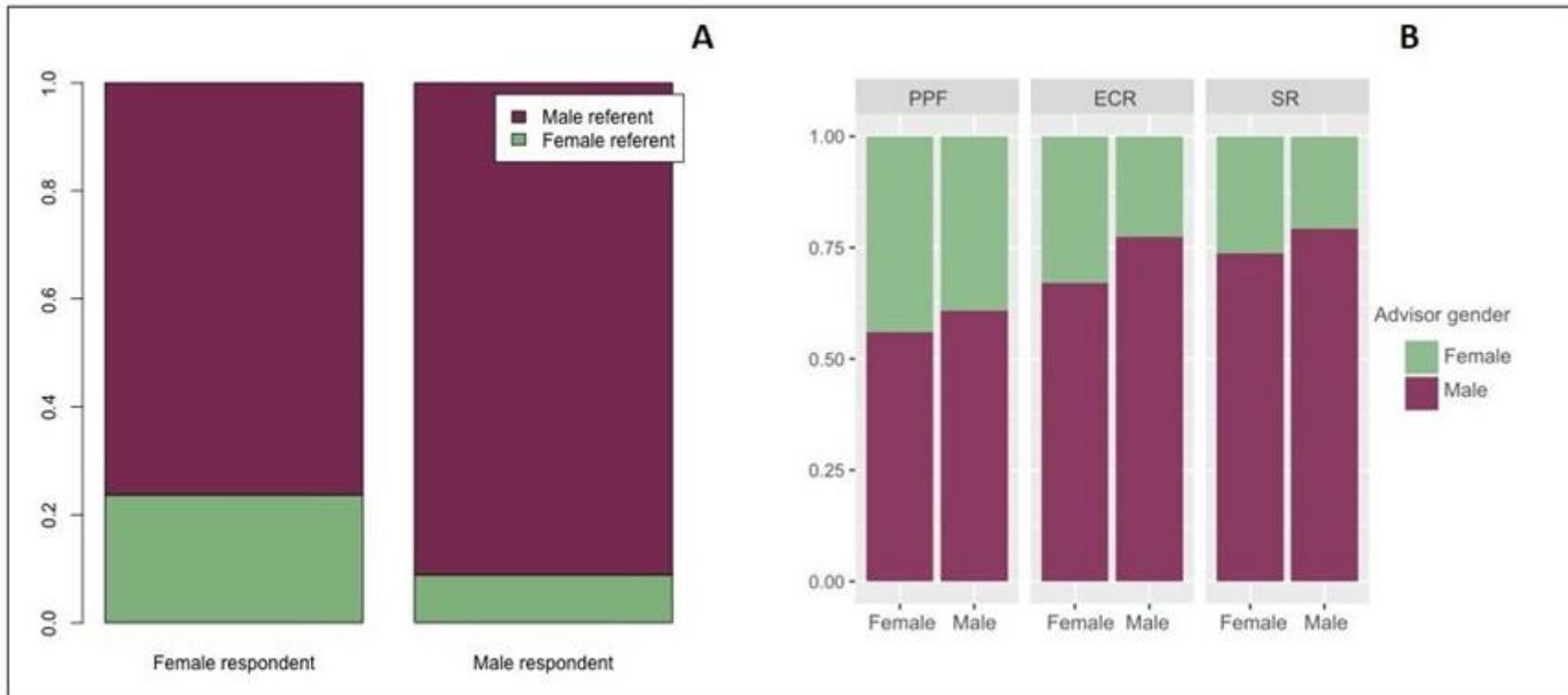


Figure 5: Percentage of (A) female (green) and male (purple) referents in their field of study chosen by female (left) and male (right) respondents; and (B) female (green) and male (purple) advisers chosen by female and male researchers while doing their PhDs. Respondents at present were PhD and Postdoc fellows (PPD), Early Career Researchers (ECR), or Senior Researchers (SR).

For our fifth question, 67% of respondents indicated that family-related issues are perceived as negatively affecting academic performance. This was not significantly different between female and male researchers (family affects performance: women = 113, men = 46; family does not affect performance: women = 51, men = 35; Chi-squared = 2.98, $df = 1$, $p = 0.084$). However, when we partitioned data in different categories of researchers, results deviated from expectations by chance at the stage of ECR, where female researchers more frequently respond that their career is being affected by family-related issues (Chi-squared = 5.32, $d.f. = 1$, $p = 0.02$; Figure 6A). Results for PPF and SR are not significant (PPF: Chi-squared = 0.86, $d.f. = 1$, $p = 0.35$; SR: Chi-squared = 0.04, $d.f. = 1$, $p = 0.30$). When we analyzed the reciprocal effect of career on family plans, results are significant for ECR, where most researchers, especially female, answered that their career had a negative effect on their family plans (Chi-squared = 5.95, $d.f. = 1$, $p = 0.01$; Figure 6B). Both PPF and SR showed no significant results (PPF: Chi-squared = 3.35, $d.f. = 1$, $p = 0.07$; SR: Chi-squared = 0.58, $d.f. = 1$, $p = 0.44$).

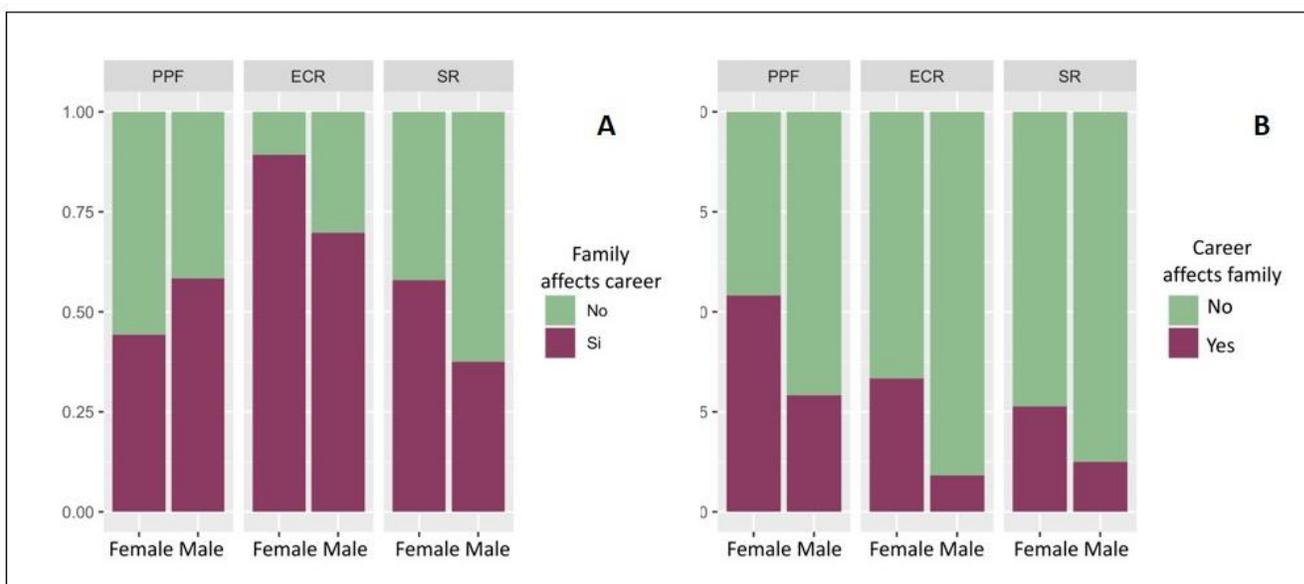


Figure 6: Percentage of female and male respondents who perceive that their family plans affect their career (A), and that their career affects their plans to have a family (B).

Regarding our sixth question, more people responded that they felt their advisers were supportive (233), rather than neutral (70) or non-supportive (37). We found no effect of gender, neither of the respondent (Chi-squared = 0.53404, $df = 2$, p -value = 0.7657) nor of the adviser (Chi-squared = 1.074, $df = 2$, p -value = 0.5845); and no effect of the level of caregiving duties (Chi-squared = 3.3353, $df = NA$, p -value = 0.5172).

DISCUSSION

As an intellectual activity, doing science demands several hours of uninterrupted concentration for qualitative production so caregiving will clearly affect productivity. Our original contribution is that the level of dedication, not just the presence or absence of caregiving duties, reflects on the ability to dedicate to work uninterrupted. And women will be more heavily affected than men. Well into the 21st century we are still facing inequities in family-related burdens. Although the above-mentioned inequities in time dedicated to work are often considered as personal issues that should remain in the private domain, we add evidence to the preexisting pattern around the globe, that the majority of caregivers are women ⁴. Indeed, “personal issues” drive the general pattern of gender disparities (Grosso et al., 2021). Thus, the distribution of caregiving responsibilities stops being a “personal” issue and should be placed in the public domain as it constantly results in a gender bias and becomes an obstacle for the advancement of women in science.

Academic performance, or productivity, did not reflect the consequences of having less continuous time to work. Women and men researchers show similar numbers of publications, which agrees with previous studies showing that women and men are equally productive in papers/year, but that women’s careers are shorter than men’s ^{7,25}. Only among doctoral and postdoctoral fellows that report having caretaking duties, we found that researchers with the highest burden are less productive. Yet the lowest number of publications was reported by fellows without caregiving duties. This may be either an artifact caused by fellows that are just starting their research career and may be younger than the average age at which academics tend to have children. It may also be a case of overcompensation and greater efficiency of people that do need to dedicate time to caregiving duties (Morgan et al., 2021). Care tasks require higher monetary investment, so researchers with people under their care may feel more preoccupied with both keeping their job and trying to promote to higher categories in their careers to earn more money. Overcompensation likely means extra energy allocated to work, adding up to the regular tasks of scientists. This overcompensation results in extra-long journeys, as evidenced by a study by Mason and Goulden (2016) where academic women aged between 30-50 years old with children reported engaging in 101 hour-long-weeks with reference to professional and home work, including caregiving. Contrastingly, men faculty with children reported an average of 88 hours per week, and men and women faculty without children, 78 hours. It is expected, therefore, that mothers will tend to drop out from academia more often than men or non-parent colleagues. Finer measures of scientific productivity reflecting quality of scientific research, not just quantity, may help us identify potential problems faced by scientists with caregiving responsibilities.

An important finding in the context of the present-day pandemic, and the idea that home-office is here to stay, is that, while working from the office might help women detach from non-work related responsibilities, women working from home are more distracted from work than their male counterparts. These results make it evident that the lockdown during the 2020 and 2021 pandemic will most probably have taken a greater toll

on female than on male scientists (Cardel et al 2020, Andersen et al 2021, King and Frederickson 2021). This will necessarily have consequences on the productivity of female scientists at present and, at least, in the near future, since the work done (or not done) today will have repercussions in publications at least two years ahead. Hence, we urge authorities to contemplate this fact when evaluating the performance of all researchers with caregiving duties, especially women, for at least two years after we have returned to normal working hours at our workplaces (Hassall, 2021).

Women tend to enter the higher categories of CONICET later than men, and achieve less frequently the higher categories in CONICET, two patterns that show that women are suffering from lower academic performance. Women may quit their careers earlier than men, or get to retirement age while at lower categories. Both scenarios are utterly unfavorable for women ecologists and, concomitantly, for the whole scientific system. If women quit early, they are indeed affected by a leaky pipeline. We must understand *why* this is happening so we can prevent it. Women that retire while in lower categories will do so with lower average salaries than men who, on average, reach higher positions in their career. Either or both of the mentioned situations may occur, and it may have serious implications for the economic independence of women embarking on a scientific career.

Researchers that answered our survey, regardless of gender, do not seem to value women's academic work as highly as men's. Moreover, women seem to undervalue their own work performance in relation to men with similar metrics. This behavior is known as impostor syndrome (Hawley 2019), where women feel inadequate for their tasks. Further, women who overcame impostor syndrome often must work harder to prove that they are capable and have equivalent expertise as men do. Being a mother of young children is one of the most strenuous moments of our lives. While at that stage, facing a highly demanding environment and the expectation of excelling academic performance from peers and evaluators, may result in a low capacity to objectively judge the value of our work.

Researchers chose more male than female advisers, and point to male referents of their field of study more frequently than to female referents. This may mean that researchers, at least in the field of ecology in Argentina, but likely more broadly, value the work and trajectory of male researchers more than that of female researchers. However, because we did not find a way to quantify the availability of female versus male researchers to choose from, we cannot rule out the possibility that there are just more men to choose from in advanced stages of the research career. The mechanism behind this pattern might be a combination of availability and preference, as women respondents do tend to choose slightly more women as advisers and as referents. It is encouraging that present-day doctoral and postdoctoral fellows chose more female advisers than did early career and senior researchers when they did their PhDs. Either because today's students value women's academic performance more than early career and senior researchers did when they did their PhDs, or whether there are more women available to choose from, those are both encouraging scenarios towards greater equity in the acknowledgement of

the scientific trajectory of female and male ecologists. Chulliver et al 2021, while studying career path lengths among herpetologists, found that women tend to have relatively shorter careers. According to their results, this pattern is not due to lower recruitment of women in the past (recruitment rates are constant and comparable between women and men since 1999). They interpret that the determining factor in the difference in path length is related to the preferential dropout rate by women. It is worth asking ourselves if in ecology the recruitment rates of the past were constant and equitable in the last 20 or 30 years.

It is expected and desirable that someone who chooses to form a family can find an equilibrium with a successful career. But this is not equally easy for men and for women. Women faculty have lower rates of marriage ^{26,27} especially among higher-ranked researchers ²⁰, tend to have fewer children or dependents in the household than men faculty. They also have children at older average ages than non-scientists, a difference that is greater than for male scientists ²⁸. Specifically, CONICET has an equal percentage of married women and men in the lower two categories of CONICET researchers, but only 40% of women in the third category tend to be married, in comparison to 70% of men ²⁰. Although the mechanism that explains these data is not clear, authors report that interviews with female researchers suggest that they decided not to form a family in order to respond to their high work-related demands. Although most researchers did not perceive conflict between family and career plans, female researchers seem to feel more strongly that their career is, indeed, affected by family, at the early stages of their career as staff researchers. The reverse is also true: women consider that their family plans are indeed affected by their career at that same stage. This may be explained by the fact that women have a shorter window of opportunity, in relation to their biological possibilities, of having children (assuming that family plans include having children). Higher-ranked researchers did not report such concern which may suggest that younger researchers are today are more aware that they have a right to have a prosperous career and to form a family, that people in later stages of their career no longer remember the pressure back when they were forming a family, and/or were not as focused on the apparent dilemma as we are today.

Finally, our finding that ecologists, regardless of gender, feel supported by their advisers when carrying family-related responsibilities is good news for Argentinean scientists and may explain the higher women/male rates in the Argentine scientific system compared to other countries ¹³. Yet we see that a minority but important 30% of answers pointing to neutral or non-supportive advisers. Lack of empathy, if not an antagonistic reaction to family-related matters from advisers, is evidently a persistent issue, that we should attend to achieve a family-friendly environment in the sciences. It would be interesting to explore further whether identifying a negative interaction between having a family and a successful career has to do with having a non-supportive adviser. This might be an important mechanism behind women that drop out of science. Public policies tending to support PhD students with caregiving responsibilities may help restrain these attitudes from advisers towards advisees and retain women in science careers.

Science institutions, be them public or private, should underpin researchers with caregiving responsibilities, especially women, as they are the ones carrying most of the burden and, most probably, suffering the academic consequences. There should not be such a dilemma as having a family or a successful scientific career. Instead, evaluation criteria should universally incorporate ways to consider the presence of children and elders under care, and facilitate sharing caregiving responsibilities. We also need to show better appreciation of the work of women scientists to create an appropriate environment for fulfillment of their potential. As mentioned by Pérez-Sedeño¹, it is not only a matter of equity and justice: no society can afford to leave half of its population out of the development of the economy of knowledge¹. Furthermore, we need a more detailed study on the mid and long term effects of caregiving responsibilities in academic performance. Having a family and its associated responsibilities are recognized by the State with different types of leaves of absence or monetary compensations in most countries. The burden of caring for children or adults should be more explicitly recognized when evaluating a researcher's performance or when assessing the possibility of a career promotion. Equity will not come naturally; thus, we need to continue to intervene in order to achieve a truly equitable work environment in science^{14,29}.

METHODS

We composed an online survey with 60 questions (Appendix 1) that was widely distributed, between November 2019 and June 2020, using professional and social networks to reach as many Argentinean ecologists as possible. Participation in the survey was voluntary and anonymous, and respondents were aware of the use of the data for research purposes. All methods were carried out in accordance with relevant guidelines and regulations of our Institution, and approved by the Committee of Ethics in Research of the National University of Tucuman and CONICET (CEI, UNT-CONICET).

For the analysis of the information obtained through the survey, in some cases we restricted the responses to researchers from CONICET in order to homogenize the universe of respondents. Also, in some cases, we grouped scientists in three categories: PhD and Postdoctoral Fellows (PPF), Assistant and Adjunct Researchers in CONICET, considered as Early Career Researchers (ECR), and Independent and Principal Researchers in CONICET, considered as Senior Researchers (SR). We left out the highest category, Superior Researchers, because we had only two answers from people in that category, and both were men. Statistical analyses were done using R Statistical Software³⁰ and Infostat³¹. We detail, for each analysis, which dataset was used.

To answer the first question, about the distribution of caregiving responsibilities between female and male scientists, we used the subset of researchers that answered that they did have caregiving responsibilities, and we quantified and compared the number of female and male researchers that chose among three options: 1. they took charge of more than 50% of their caregiving responsibilities, 2. they took charge of half of

caregiving responsibilities, and 3. they took charge of less than 50% of their caregiving responsibilities. We analyzed these data with a Chi-squared test.

To answer the second question, related to the possibilities of dedicating to work in relation to caregiving responsibilities and gender, we quantified 1. the total number of uninterrupted working hours and 2. the amount of time dedicated to non-work-related demands during working hours, as proxies to fully dedicating and concentrating on work tasks only, and to the quality of working conditions, respectively. We also quantified the number of papers published in indexed journals as first author, as reported by respondents, as a proxy to academic performance. We compared those proxies between respondents (a) with different levels of caregiving responsibilities, and (b) of different genders. When analyzing caregiving duties in relation to academic performance, we analyzed separately the answers for the three categories of researchers described above (PPF, ECR, and SR). This is because the expected number of publications, the distribution of caregiving duties and genders are very different among these categories. The number of uninterrupted hours dedicated to work were analyzed using a t-test and an ANOVA, while the number of publications were analyzed using an ANOVA. The amount of time dedicated to non-work-related demands while working from the office or from home, was analyzed with a Chi squared test; for this, answers were divided into three categories: 1. no time at all, 2. less than one hour, 3. one hour or more. Levels of caregiving responsibilities were characterized as: 1. people that reported not to have any caregiving responsibilities; 2. people that had such responsibilities but assumed less than half of those responsibilities; and 3. people with caregiving responsibilities that assumed half or more than half of caregiving duties. In order to homogenize the standards of productivity to which researchers are subject, for the second and third questions we included only researchers from CONICET.

To answer the third question, whether career paths of female scientists differ from those of males, we looked at the average age at which researchers entered the different academic categories at CONICET, separated by level of caregiving responsibilities and gender. When needed, we analyzed these data using Kruskal-Wallis tests.

To answer the first part of the fourth question, how researchers value their own academic performance, and how that is related to gender, we asked the respondents to value their academic performance, classifying themselves as being below, equal, or above average relative to their colleagues. To test whether the probability of classifying themselves in one of the three categories was different for women and men, given similar academic performance (i.e., number of papers), we applied multinomial logistic regression using *multinom()* function in *nnet* package³² in R statistical Software³⁰. To answer the second part of the fourth question, how researchers value the academic performance of others, and how that is related to gender, we quantified: 1. the number of female researchers chosen when asked to name three referents in their field of study, and 2. the frequency of female PhD advisers. For the former, because we did not want to bias responses, we only asked for the names of three referents and later sexed them by

looking them up in the world-wide web. We compared the number of female and male advisers and referents between female and male respondents using Chi-squared tests.

To answer the fifth question, about the perception of respondents of the interaction between having a family and a successful career, we compared how many female and male respondents answered whether their family situations, as they had defined it in previous questions, facilitated, negatively affected, or had no effect at all in their academic performance. Conversely, we also asked whether they found an effect of their career on their family plans. For both questions we analyzed the data using Chi-squared tests.

To answer the sixth question, about the level of support from their PhD advisers in relation to gender, we compared answers from female and male respondents, who could choose from a scale that went from 1 (I got no support at all from my adviser) to 5 (he/she was very supportive). We also looked at the incidence of having a female or male adviser in the answer, and of having different levels of caregiving responsibilities. We analyzed answers using Chi-squared tests.

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AUTHOR CONTRIBUTION

S.B.L., G.F., M.G.N.M. and M.P.R. came up with the idea, designed the survey, and drafted the structure of the manuscript. S.B.L. wrote the first draft of the manuscript and shaped the final version for submission. S.B.L., A.N. and M.L.S.S. gave the final structure to the paper. A.N. and M.L.S.S. improved figures and tables. All authors helped with analyses and writing. Authors up to M.P.Q. are listed in order of contribution. Thereafter, by alphabetical order.

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- [Appendix1Survey.docx](#)