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COVID-19 and the gender gap in research productivity: understanding the effect of having primary responsibility for the care of children

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ABSTRACT

In this paper we contribute to the emerging literature on the effect of the COVID-19 pandemic on the gender gap in research productivity. We extend previous studies by considering men and women academics from science and non-science disciplines through an analysis of data from academics at 14 universities across two countries (seven in Australia and seven in Canada) and focusing on the role of primary caregiving. Our empirical approach used logistic regressions and the Blinder–Oaxaca decomposition technique. The latter enabled us to ask: ‘How much of the gender gap in perceived productivity during the pandemic is due to gender differences in primary care responsibilities?’ Within the sample (N = 2,817) of academics, 33% of women and 25% of men reported that their perceived publication ability decreased a lot during the pandemic. This is an eight percentage-point gender gap in perceived publication ability. Statistical analysis revealed that two-fifths (40%) of this gap may be explained by gender differences in having primary responsibility for the care of children. Gender differences in other characteristics such as age, discipline, and increased teaching and administrative work were not, as a group, significant. There were also no differences between Australia and Canada. The findings are important, particularly for the pursuit of gender equality within academia. In the absence of specific mitigating interventions, research disruptions in 2020 may have long-lasting career scarring effects (e.g. hiring, promotion, tenure) and, as a result, see women further disadvantaged within the academy.

KEYWORDS

COVID-19; higher education; research productivity; primary caregiving; gender equality; academia

Introduction

The COVID-19 pandemic was a serious global crisis which, among other things, revealed deep structural inequalities in society (Pirtle and Wright 2021). It significantly disrupted supply chains and is projected to have long lasting implications on work arrangements and productivity. In the higher education sector, it amplified existing gender inequalities (Viglione 2020; Górska et al. 2021; Peetz et al. 2022b; Walters et al. 2022). A growing number of studies show a negative impact of the pandemic on various measures of academic research productivity, particularly for women and mothers (Gao et al. 2021;

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Myers et al. 2020; Staniscuaski et al. 2021). Some studies have focused on a sub-set of academics (in the sciences) or a specific region, or have operationalised childcare as the presence and/or age of children. Fewer studies have examined the specific role of the primary caregiver, taking it for granted that mothers tend to play a greater caregiving role. Studies such as those listed above measure various facets of research productivity (ability to initiate new projects, ability to submit grants, time devoted to research, paper submission rates and ability to meet research deadlines).

In this paper we extend the literature through an analysis of survey data collected from academics across disciplines in seven Australian and seven Canadian universities in 2020. Our dependent variable captured the effect of the pandemic on a particular facet of research productivity: the perceived ability to finish or submit research papers. Our empirical approach used logistic regressions along with the Blinder (1973) and Oaxaca (1973) statistical decomposition technique. The advantage of the latter is that it allows the researcher to segment the observed gender gap into a portion that may be 'explained' by gender differences in characteristics such as primary care responsibilities, degree of teaching and administrative work and a component that is 'unexplained' (i.e., arising from gender differences in the coefficients). It allowed us to ask: *'How much of the gender gap in perceived research productivity during the pandemic arises from gender differences in primary care responsibilities?'* In other words, the technique sheds light on the source of the gender gap in perceived research productivity. It is a technique commonly used by labour economists to study gender differences in wages (e.g. Blau and Kahn 2017).

Our results show that the pandemic disproportionately disrupted the perceived research productivity of women and men with primary care responsibilities. Though our focus is on women as the group more likely to carry care burdens, we flag our findings for primary caregiver fathers as an area in need of additional research. The decomposition analysis shows that the main source of the gender gap in perceived research productivity is the gender difference in primary care responsibilities.

The next section provides a review of relevant literature. Subsequent sections describe the data and research method, present the findings, and discuss the results.

Background and previous studies

The sudden shift to working-from-home in 2020 was welcomed in some quarters due to its potential to 'shock' prevailing norms around care and housework tasks and change the 'doing' of gender (Chung et al. 2021). However, the hoped-for change in the gender regime and social norms did not eventuate. Within heterosexual couples a disproportionate share of domestic care-work and unpaid labour continued to fall on women (Walters et al. 2022).

The pandemic had a considerable impact on women in employment and mothers in particular given the closure of schools and daycare centres (Gao et al. 2021; Myers et al. 2020; Walters et al. 2022). There is strong evidence that the bulk of the care-work that arose during the pandemic fell on women, regardless of class, employment, and income (Cortes and Forsythe 2020). There is also evidence of a racial intersection (Staniscuaski et al. 2021). In black communities, women were expected to 'care for families and whole communities without compensation and support' (Pirtle and Wright 2021, 172). Jackson (2004) describes the phenomenon as 'other mothering'. The general view is that the economic disruption caused by COVID-19 will leave long lasting inequalities (Alon et al. 2020). In academia, the effects may play out in gendered and racialised hiring and in career advancement (Gao et al. 2021; Myers et al. 2020; Staniscuaski et al. 2021; Walters et al. 2022).

University workplaces are highly gendered, with the academic culture undervaluing activities in which women are over-represented (e.g. service, teaching, administration) and placing a higher premium on activities in which men are over-represented (e.g. research) (Britton 2017). A particular feature of academic work is the culture of long hours and, with it, the pressure to be productive through grants and publications (Currie and Eveline 2011). Such ideal worker norms 'have tangible implications' for women and increase the potential for time conflict when academics are forced to work from home (Lockhart 2021). Knowledge work is another characteristic of academic work (Peetz et al. 2022b). The extent to which working-from-home may facilitate time for sustained (i.e.,

uninterrupted) knowledge work may relate to the home environment, the presence of dependent children and the way individuals create, maintain, and manage boundaries (Walters et al. 2022).

A growing body of research from many countries suggests that academic women have been disproportionately affected by the COVID-19 pandemic, especially those with dependent children (Carreri and Dordoni, 202; Deryugina, Shurchkov, and Stearns 2021; Gao et al. 2021; Jung, Horta, and Postiglione 2021; Myers et al. 2020; Staniscuaski et al. 2021; Walters et al. 2022). In disciplines such as economics and science, technology, engineering, mathematics (STEM), evidence at the start of the pandemic noted that women were publishing less and starting fewer projects when compared with men (Viglione 2020). Examining scientists in Europe and the US at the beginning of the pandemic, Myers et al. (2020) found an approximately 10% decrease in time spent on research across all respondents, with an additional decrease of 5% for women, and 17% for mothers of young children. Using a comparable sample of scientists, Gao et al. (2021) found a similar decrease in the initiation of new projects in the early stages of the pandemic. They reported that productivity had nearly recovered a year later, but not for all; female caregivers with young children continued to lag. Similar results were reported by Staniscuaski et al. (2021) using a sample of just over 3,000 Brazilian academics and measuring paper submission rates and ability to meet research deadlines. Qualitative research also indicates that women shouldered more teaching responsibilities following the sudden shift to online teaching and cuts to professional support staff (see Kasymova et al. 2021). Several studies suggest that the pandemic has intensified pre-existing challenges for academic women or academic mothers (Bowyer et al. 2022; Carreri and Dordoni 2020; Guy and Arthur 2020). Examples of the latter include gender inequalities in the allocation of teaching and service work (Misra et al. 2021) and the shouldering of emotional labour (O'Meara et al. 2017).

Data and research method

Our analysis employed data from a unique study of university staff working across seven Canadian and seven Australian universities in 2020. These two countries were selected for their similarity in terms of culture and political structures. This between-country resemblance has been documented elsewhere (Chidiac 2018: 80). Their respective tertiary education systems also share key characteristics such as funding models, systems of tenure, senior leadership appointments, collegial process, and union density (see Shaw 2014; Peetz et al. 2022a; 2022b). The pandemic brought the same changes to home-working and remote course delivery to universities in both countries who each faced lockdowns and school closures; however, the timing and severity of public restrictions and the austerity response of university administrators differed. Austerity measures were more pronounced in the Australian higher education context (see Peetz et al. 2022a).

The data were collected through a cross-sectional online survey aimed at understanding the effects of COVID-19 and changed working arrangements on university work.¹ Universities formed a convenience sample (comprising institutions where research team members were able to persuade management to allow participation), but in each country the sampled universities were representative of universities as a whole as they ranged in size, geographical location and teaching and research intensity. Within each university, staff were invited via email to participate in the survey. Confidentiality was assured. The survey was administered through July-October 2020. The number of respondents per university ranged from 173 to 1,825 with a median of 696. Usable responses were received from a total of 11,288 university workers which included 7,420 administrative staff and 3,601 faculty. The remainder were university managers, librarians or archivists or did not state their position. In this paper we only use the $N = 3,061$ responses from faculty with duties that include some combination of research, teaching and service.²

Although the survey asked respondents about their gender (with response options being 'man', 'woman' or 'other (define)') there were too few observations in the academic sample to examine non-binary respondents separately. We restricted the sample accordingly, reducing it to 3,548 respondents. A small share (6.8%) of remaining respondents also identified as being LGBTIQ and we included a dichotomous variable to separately capture any effect associated with such identification. After conditioning

on observations with observable data in our regressions we were left with a sample of 2,817 men (38%) and women (62%) academics.³ Faculty from Australia represented 59% of the sample.

Dependent variable

Our dependent variable was a measure of perceived research productivity: 'Do you consider the following things associated with your work at [University] increased, decreased or remained the same as a result of the changes associated with moving from pre-Covid to Covid working arrangements? ... your ability to finish or submit research papers.' Responses were provided on a five-point scale (decreased a lot, decreased a little, stayed about the same, increased a little, increased a lot) plus a 'not applicable' option. A large share of women (58%) and men (48%) reported that their ability to finish or submit research papers declined a little or a lot (Table 1). The 10-percentage point gender gap in perceived research productivity was highly significant. We subsequently employed two dependent variables: (a) 'DEC' which is equal to 1 if perceived publication ability decreased a little or a lot; (b) 'DEC_{lot}' is equal to 1 if reported publication ability decreased a lot.

Independent variables

Table A1 (in the appendix) details the construction of the dependent and the independent variables included in the regressions. Summary statistics are also provided. Our empirical analysis controlled for the gender of the respondent. While we were unable to separately consider race, we did control for whether the respondent self-identified as Indigenous or another visible minority. We also controlled for age, with the age variables constructed from grouped information on the decade born. Summary statistics show that 42% of the sample was aged 51 years or more. On average, women were younger than men. We did not control for academic level as we are missing this information for 6.8% of the sample and age and academic level are highly correlated.

Given previous research showing the effect of the presence, number and age of children on research productivity (Gao et al. 2021; Myers et al. 2020; Staniscuaski et al. 2021; Walters et al. 2022), our key variable of interest was the binary variable *MainCarer*. This variable was set equal to 1 if the respondent indicated that they had dependent children *and* that they either always or usually had primary responsibility for the care of their children. Summary statistics show that 5.5% of men and 21.9% of women were 'MainCarers'. A subset of these individuals were sole parents (25% among men and 20% among women).

We also controlled for discipline area via a binary variable that was equal to 1 if the respondent was in a STEM discipline and zero otherwise. Other controls included a binary variable set at 1 if the time spent on teaching activities increased and 0 otherwise, another binary variable measuring whether time spent on administrative work increased, and a series of contextual variables detailed below.

Relative to men, women were less likely to be in a STEM discipline and more likely to indicate that their time spent on administrative and service work increased during the pandemic. The extent of working-from-home was also statistically greater for women than men. Women were more likely than men to agree with the statements indicating that it was clear what was expected in their jobs, that they had a separate space at home to do university work and that the university provided adequate support to enable them to work at home. Proportionately fewer women agreed that they

Table 1. The effect of changed working arrangements on the perceived ability to finish or submit research papers.

	% of respondents				
	Decreased a lot	Decreased a little	Stayed about the same	Increased a little	Increased a lot
Men	25.3	23.1	27.0	18.3	6.4
Women	33.3	24.7	22.4	13.5	6.1
All	30.2	24.1	24.2	15.3	6.2

Notes: N = 1,083 men; N = 1,734 women; N = 2,817 total.

had good equipment at home. The share of men and women reporting an *increase* in connections with colleagues following the changed working arrangements was low for both groups, although it was higher for women (9.4%) than men (6.6%). Both groups reported that their working time was increasingly disrupted by other people, with this share also higher among women.

Research approach

We employed a two-staged empirical approach. In the first stage we estimated six logistic regressions. These are reported in [Table 2](#). The first three used the dependent variable 'DEC' (perceived publication ability decreased a little or a lot) and the second three used the dependent variable 'DEClot' (perceived publication ability decreased a lot). In columns (1) and (4) the sample included men and women. Columns (2) and (5) included just men, while columns (3) and (6) included just women. Where the sample was comprised of men and women a dummy variable controlled for gender.⁴

The second stage employed the statistical decomposition technique first suggested by Oaxaca (1973) and Blinder (1973). As noted, the approach enabled us to separate the observed gender gap in perceived ability to submit research papers into 'explained' and 'unexplained' components. More specifically, it allowed us to ask: 'How much of the gender gap in perceived research productivity during the pandemic arises from gender differences in primary care responsibilities?' and 'How much of the gender gap in perceived research productivity relates to gender differences in other characteristics such as teaching and administrative work?'

The Oaxaca–Blinder technique required first fitting two regressions. In the linear case the approach may be written as follows.

$$DEC_M = \alpha_M + \beta_M X_M + \varepsilon_M \quad (1)$$

$$DEC_W = \alpha_W + \beta_W X_W + \varepsilon_W \quad (2)$$

where the subscripts 'M' and 'W' denoted men and women, respectively. 'X' is the set or vector of covariates thought to impact perceived research productivity (as previously described), 'ε' is an error term; 'α' is a constant to be estimated; and 'β' is a vector of coefficients to be estimated. After estimation, subtracting [equation \(2\)](#) from [equation \(1\)](#) and rearranging terms gives:

$$\text{Gender Gap in DEC} = (\bar{X}_M - \bar{X}_W)\hat{\beta}_M + \bar{X}_W(\hat{\beta}_M - \hat{\beta}_W) + (\hat{\alpha}_M - \hat{\alpha}_W) \quad (3)$$

The component $(\bar{X}_M - \bar{X}_W)\hat{\beta}_M$, is the amount of the gender gap in 'DEC' that may be attributed to gender differences in the controlled for characteristics. This is commonly referred to as the 'explained' component. It shows what share of the observed (raw) gender gap may be accounted for (explained) by gender differences in characteristics such as teaching and administrative load and primary care responsibilities. The second component, $\bar{X}_W(\hat{\beta}_M - \hat{\beta}_W)$, is the amount that may be attributed to differences in the regression coefficients ('β') between men and women. The third term, $(\hat{\alpha}_M - \hat{\alpha}_W)$, is the amount of the gap that can be attributed to differences in the constant terms, 'α', of men and women. Taken together the second and third terms are typically referred to as the 'unexplained' component. As we used a non-linear estimator (logit regression) in this analysis we employed the 'Fairlie' command in Stata to undertake the decomposition (Jann 2006).

Results

Logit regressions – stage 1

[Table 2](#) reports the results from the estimation of the logit regressions. Column (1) shows that there was a 9.3% gender gap in perceived publication difficulty (women were more likely than men to report that publication ability decreased). Those with primary responsibility for the care of children ('MainCarer') were 11.2% more likely than those without primary responsibility for the care of children to report increased publication difficulty. When disaggregated by gender, the results in Columns (2) and (3) show that the care penalty was 20.2% among men and 10.4% among women.

Table 2. Logit regressions: perceived ability to finish or submit research papers during the pandemic, marginal effects.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Y = DEC (=1 if perceived ability decreased a little or a lot)			Y = DEC _{lot} (=1 if perceived ability decreased a lot)		
	All	Men	Women	All	Men	Women
<i>Woman</i>	0.093*** (0.022)	-	-	0.060*** (0.019)	-	-
<i>MainCarer</i>	0.112*** (0.034)	0.202** (0.080)	0.104*** (0.038)	0.118*** (0.026)	0.150*** (0.054)	0.118*** (0.033)
<i>NumChildren</i>	0.019 (0.013)	0.017 (0.019)	0.017 (0.017)	0.011 (0.011)	-0.001 (0.015)	0.018 (0.016)
<i>LGBTIQ</i>	-0.006 (0.042)	-0.099 (0.075)	0.060 (0.050)	-0.011 (0.036)	-0.017 (0.054)	-0.010 (0.047)
<i>Racial Minority</i>	-0.062** (0.030)	-0.150*** (0.049)	-0.002 (0.038)	-0.026 (0.025)	-0.037 (0.039)	-0.020 (0.033)
<i>Age [?] 30</i>	-0.036 (0.057)	0.059 (0.103)	-0.080 (0.067)	-0.101* (0.058)	-0.067 (0.090)	-0.112 (0.076)
<i>Age31-40</i>	0.011 (0.028)	0.017 (0.047)	0.005 (0.036)	-0.010 (0.024)	-0.037 (0.038)	0.003 (0.033)
<i>Age41-50</i>	-0.032 (0.027)	-0.031 (0.045)	-0.032 (0.035)	-0.007 (0.023)	0.014 (0.035)	-0.017 (0.031)
<i>Age_missing</i>	-0.109 (0.130)	-0.037 (0.193)	-0.181 (0.177)	-0.040 (0.111)	0.120 (0.111)	-0.313 (0.214)
<i>STEM</i>	-0.104*** (0.022)	-0.143*** (0.036)	-0.068** (0.027)	-0.092*** (0.018)	-0.077*** (0.027)	-0.099*** (0.025)
<i>Teach_Inc</i>	0.177*** (0.030)	0.105** (0.043)	0.232*** (0.040)	0.119*** (0.027)	0.067* (0.035)	0.157*** (0.038)
<i>Teach_na</i>	-0.062* (0.034)	-0.150*** (0.055)	0.005 (0.043)	-0.037 (0.031)	-0.040 (0.045)	-0.025 (0.043)
<i>Admin_Inc</i>	0.166*** (0.022)	0.091** (0.035)	0.207*** (0.027)	0.137*** (0.019)	0.087*** (0.027)	0.166*** (0.026)
<i>Admin_na</i>	0.147** (0.058)	0.189* (0.105)	0.125* (0.069)	0.166*** (0.046)	0.164** (0.070)	0.167*** (0.061)
<i>WFH</i>	-0.003 (0.007)	0.002 (0.009)	-0.008 (0.009)	0.005 (0.006)	0.009 (0.009)	0.003 (0.008)
<i>Clarity</i>	-0.075*** (0.022)	-0.063* (0.036)	-0.080*** (0.028)	-0.094*** (0.019)	-0.054* (0.028)	-0.116*** (0.025)
<i>Space</i>	-0.033 (0.028)	-0.048 (0.046)	-0.023 (0.035)	-0.054** (0.023)	-0.088** (0.035)	-0.029 (0.031)
<i>Equipment</i>	-0.029 (0.028)	-0.006 (0.045)	-0.037 (0.035)	-0.002 (0.023)	0.039 (0.035)	-0.029 (0.031)
<i>Support</i>	-0.037 (0.023)	-0.037 (0.039)	-0.044 (0.029)	-0.041** (0.020)	-0.043 (0.031)	-0.042 (0.027)
<i>Colleagues</i>	-0.114*** (0.039)	-0.163** (0.068)	-0.092** (0.047)	-0.045 (0.031)	-0.106* (0.060)	-0.020 (0.039)
<i>Disruption</i>	0.243*** (0.023)	0.270*** (0.037)	0.231*** (0.028)	0.114*** (0.019)	0.117*** (0.028)	0.116*** (0.025)
<i>Australia</i>	0.023 (0.022)	0.048 (0.036)	0.006 (0.029)	0.023 (0.019)	0.023 (0.027)	0.025 (0.026)
<i>flag_wfh</i>	0.048 (0.184)	0.065 (0.242)	-0.025 (0.242)	-0.085 (0.135)	-0.191 (0.182)	-0.064 (0.204)
<i>flag_clarity</i>	0.003 (0.174)	-0.000 (0.242)	0.047 (0.250)	0.086 (0.137)	0.073 (0.182)	0.086 (0.191)
<i>flag_support</i>	0.033 (0.067)	-0.031 (0.115)	0.067 (0.081)	0.034 (0.065)	-0.031 (0.096)	0.074 (0.086)
<i>flag_disrupt</i>	-0.405*** (0.095)	-0.699*** (0.258)	-0.308*** (0.102)	-0.164** (0.068)	-0.189 (0.120)	-0.150* (0.081)
Pseudo R ² (%)	14.6%	13.8%	15.7%	12.3%	9.9%	13.7%
Observations	2,817	1,083	1,734	2,817	1,083	1,734

Notes:

- Standard errors are in parentheses and are corrected for heteroskedasticity.
- Significance given by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

There were several other significant results. Around 56% of faculty reported that the time they spent on teaching activities (including preparation) increased a little or a lot during the study period, men slightly

more so than women. The effect of this on perceived publication ability is given by the coefficient on the variable *'Teach_Inc'*. It shows that those reporting an increase in time spent on teaching were 17.7% more likely to perceive that publication ability had deteriorated. The disaggregated results (columns (2) and (3)) show that among men the teaching penalty was 10.5% and for women it was 23.2%. Those reporting that their time spent on service and administrative work had increased a little or a lot (*Admin_Inc*) were also 16.6% (column (1)) more likely to report that their perceived ability to finish or submit research papers had decreased. Again, there are significant differences by gender. In the case of men the perceived publication penalty on this variable was 9.1% and among women it was 20.7%. Having clear expectations about one's job role was also a significant predictor of decreased research productivity; both men and women were less likely to report that their perceived ability to publish had suffered if they were clear about their job roles. Those who reported that their connection with colleagues increased a little or a lot were significantly less likely to report that their perceived publication ability had decreased. Academics employed in a STEM discipline area were 10.4% *less likely* than their counterparts elsewhere to report perceived publication difficulty (column (1)). This may relate to differences in the way STEM and non-STEM academics collaborate or perhaps to the level of engagement in COVID-related research, although further research would be required to test these hypotheses. There was no significant difference in the effect of changed working arrangements on publication ability by country.

Oaxaca-blinder decompositions – stage 2

Table 3 reports the decomposition results. As before, two dependent variables were considered – *'DEC'* (perceived ability to finish and submit papers declined a little or a lot) and *'DEClot'* (perceived ability to finish and submit papers declined a lot). As shown in row (3), there was a 9.6 percentage point gender gap in *'DEC'* and an 8.0 percentage point gap in *'DEClot'*. Focusing first on *'DEC'*, column (1) shows that gender differences in the characteristics controlled for in the regressions in Table 2 accounted for 30% of the 9.6 percentage point gender gap (row (6), column (1)). In other words, nearly one third of the observed gender gap may be explained by the variables in the regression. The detailed results in the bottom panel (rows (7) and (8)) show that gender differences in primary responsibility for the care of children (*MainCarer*) accounted for around one-quarter (24%) [$-0.023/-0.096$] of the 9.6 percentage point gender gap. In short, having primary responsibility for the care of children was the main factor explaining gender differences in perceived ability to finish or submit research papers during our study period. Gender differences in incidence of other characteristics as a group (e.g. time on teaching and/or administrative work or gender differences in academic discipline) have no net statistical impact in explaining the 9.6 percentage point gender gap (the gender differences in incidence were much less than gender difference in effects). In other words, they are not the source of the observed gap (row (8) of Table 3).

Column (2) of Table 3 examines the gender gap among those reporting that their publication ability decreased a lot. Again, row (6) shows that the variables in the regression explained nearly two-fifths (38%) of the observed gender gap at row (3). The detailed results at row (7), column (2) show that, on its own, gender differences in being the main carer explained 40% of the 8.0 percentage point gap in perceived publication ability. As with the estimates in column (1), gender differences in other characteristics, as a group, are not significant drivers of the gap.

Discussion

The coronavirus pandemic that commenced in 2020 had a dramatic effect on how and where work was done and, for many, blurred the boundaries between work and non-work. Research elsewhere shows that it had a particular adverse impact on the research productivity of scientists and other academics with dependent children (Gao et al. 2021; Myers et al. 2020; Staniscuaski et al. 2021). In this paper we contribute to this emerging literature on the gendered effect of the pandemic on research productivity through a study of academics in Australian and Canadian universities in

Table 3. Oaxaca-Blinder decomposition of the gender gap in perceived publication ability.

	(1)		(2)	
	$Y = DEC$		$Y = DEC_{clot}$	
	Coef.		Coef.	
(1) Men	0.484		0.253	
(2) Women	0.580		0.333	
(3) Gender Gap [(1)-(2)]	-0.096*** (0.019)		-0.080*** (0.016)	
(4) Due to differences in characteristics (explained component)	-0.029* (0.015)		-0.030*** (0.011)	
(5) Due to differences in coefficients (unexplained component)	-0.068*** (0.018)		-0.049*** (0.012)	
(6) Share of gender gap explained (%) [(4)/(3)%]	30%		38%	
Explained component: details				
	Coef.	% of Gender Gap Explained by:	Coef.	% of Gender Gap Explained by:
(7) Gender differences in 'MainCarer' responsibilities	-0.023*** (0.008)	24%	-0.032*** (0.011)	40%
(8) Gender differences in all other variables as a group	-0.006 (0.007)	7%	0.002 (0.006)	-2%

Notes:

1. The logit regressions control for all variables listed in Table 2.

2. The percentages may not sum due to rounding errors.

3. Standard errors in parentheses.

Significance given by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

2020. Our analysis extends previous studies by considering all academics (men and women; not just scientists) and even found a greater research productivity penalty among non-STEM academics than their STEM counterparts. We used a statistical technique that allowed us to shed light on the source of the gender gap in perceived research productivity. Our unique contribution is in showing that the gender gap in perceived research productivity during the early days of the pandemic relates to gender differences in having primary responsibility for the care of children.

Like others, we found evidence of a steeper (perceived) productivity decline for women during the pandemic (Barber et al. 2021). Within our sample, 58% of women and 48% of men perceived that their ability to finish and submit research papers deteriorated. Important correlates of this effect included caring responsibilities, discipline area (non-STEM) and increased teaching and administrative work. Other research has demonstrated the significant disruptive effects on academic work associated with having care giving responsibilities (Deryugina, Shurchkov, and Stearns 2021). This effect has been observed in many other parts of the world – in the US and Europe (Gao et al. 2021; Myers et al. 2020), Italy (Carreri and Dordoni 2020), Hong Kong (Jung, Horta, and Postiglione 2021), South America (Staniscuaski et al. 2021), South Africa (Walters et al. 2022). We add our study of Canada and Australia to the mix and, importantly, we show that it is being the primary carer, rather than the mere presence or number of children, that matters.

Overall, we found a 9.6% gender gap in perceived publication difficulty. One quarter (24%) of this gap may be explained by gender differences in having primary care responsibilities. When we confined the analysis to those reporting 'a lot' of perceived publication difficulty (33% of women and 25% of men) we found that two-fifths (40%) of the 8.0 percentage point gender gap in perceived publication difficulty may be explained by gender differences in primary care responsibilities. These are substantial shares. Moreover, the estimates showed that, on its own, it was the *MainCarer* variable that drove the explained result. The other variables as a group were not significant drivers of the gap.

Several mechanisms may explain why having primary responsibility for the care of children would have had such a strong effect. The most obvious is that children consumed time that was otherwise available for research and interrupted the capacity for sustained knowledge work that is critical to publication success (Peetz et al. 2022). This would have been particularly the case where primary caregivers

were also responsible for home-schooling (Gorska et al. 2021) and more so in the case of sole parents. We are unable to say precisely what mechanism(s) are at play; however, we can say with certainty that the gender gap in perceived ability to publish reflected the gender differences in caring. The results support previous findings on the existence of gender inequalities in the division of domestic labour and research that showed that the disproportionate burden of care-work fell on women during the pandemic (Cortes and Forsythe 2020; Gao et al. 2021; Myers et al. 2020; Staniscuaski et al. 2021). Without discounting this finding, our results also point to the less frequently discussed care penalties experienced by the smaller number of fathers who are primary caregivers, often because they are sole parents. The notion of a 'fatherhood penalty' (Steffens, Preuß, and Scheifele 2019) in academia requires additional research particularly as the norms of the ideal academic worker may particularly marginalise and invisibilize primary caregiver fathers as the caregiver role is less expected for fathers (Bear and Glick 2017).

The negative productivity shock experienced by mothers may feed into already problematic narratives and stereotypes about mothering and academic careers, where the latter is portrayed as a moral calling that requires intensive, continuous, and often exclusive investment (Thébaud and Taylor 2021). It may stymie efforts to redress the gender imbalance in universities. Research also shows that those with primary care responsibilities are vulnerable to career scarring (lost opportunities for learning and career advancement, trends of lower salaries, higher unemployment) and stunted career growth because of macroeconomic shocks (e.g. recessions, pandemics) (Heggness 2020). If the perceived publication difficulties identified in this study translate into actual research outcomes for the academics in our sample, then primary caregivers are at risk of significant career penalties in the absence of any direct interventions. At its worst we may see a 'lost generation' of women researchers (Harrop et al. 2021). Moreover, although men are considerably less likely to be the primary care giver in our sample, the parenting (career) penalty facing these men is likely to raise analogous issues to those faced by women.

The challenge for universities and other workplaces is to ensure that the cultural and structural factors that contributed to gender inequalities in the pre-pandemic world are not magnified in the post-pandemic world. This will require deliberate interventions to reconsider what work is valued and how this relates to the gendered division of labour within universities. As a starting point, this could involve immediate release for a finite period from some or all teaching and/or service for academics who were primary carers during the most challenging early stages of the pandemic. This would allow these researchers to recharge, refocus and catch-up for the time lost. Alternatively, there should be some reduction over a longer period in the teaching and administrative burdens for people who were primary caregivers during the pandemic. It also requires a rethink of hiring, tenure and promotion criteria, and pay-for-performance evaluation processes covering the pandemic period such that individuals do not fall behind in career progression or total compensation over the life course. A permanent rethink of these policies and other initiatives that address the long-hours and competitive culture in academia is also warranted. The evidence in this study suggests that women and men who provide primary care – and mothers form the bulk of this group – warrant a different suite of research resources (time, funding, flexibility, etc.) that is most valuable *to them* and that accounts for the barriers primary care-giving places in the way of research productivity. That said, the explanations and the policy responses need to extend beyond the workplace into the domestic sphere, and much more needs to be done, including by universities (who already impinge into household time) to promote an equal distribution of care responsibilities within the household.

Notes

1. The project was approved by the Human Research Ethics Committees at each participating university. The survey included an informed consent statement and if the user consented they continued to the first page of the survey questions.
2. From the sample of male and female academic respondents (N=3,548) we dropped 19% who were academics but did not identify as having research responsibilities (reflecting a higher number of contract academics and teaching staff without research responsibilities).

3. We lost a further 56 observations with missing information on children, teaching and administrative work, home working environment, adequacy of home equipment, and connectivity with colleagues. To minimise the loss of a further 116 observations we assigned the mean value to six observations with missing information on the working from home (WFH) variable (see Appendix for a description of variable labels). In the regression, we included a flag variable coded as 1 if working-from-home information was observed. In the case of the three dummy variables labelled 'Clarity', 'Support' and 'Disruption', there were, respectively, 13, 66 and 39 observations with missing data. In each case we assigned these observations to the base category (i.e. gave them a value of 0). In the regression we included a flag variable for each of these dummies. If there were systematic differences in the sample with missing information on these four variables this would be captured in the respective flag variable. Interpretation of the coefficients on the dummy variable requires addition of the dummy variable and its flag. As shown, the only flag that was significant was that associated with the dummy variable 'Disruption'. The analysis is robust to the exclusion of these flag variables. It is also robust to the exclusion of these 116 observations.
4. We do not use the gender interacted variable in the regression as it does not lend itself to the Oaxaca-Blinder statistical decomposition.

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Appendix:**Table A1.** Variable definition and descriptive statistics.

Variable label	Variable description	(1) All	(2) Men	(3) Women
<i>Pubs</i>	Perceived ability to finish or submit research papers (1 = decreased a lot; 5 = increased a lot)	2.4 (1.2)	2.6 (1.2)	2.3 (1.2)
<i>DEC</i>	=1 if perceived ability to finish or submit research papers decreased a little or a lot; =0 otherwise.	54.0%	48.4%	58.0%
<i>DEClot</i>	=1 if perceived ability to finish or submit research papers decreased a lot; =0 if otherwise.	30.0%	25.3%	33.3%
<i>Woman</i>	=1 if indicated they identify as a woman; =0 if as a man.	61.6%	-	-
<i>MainCarer</i>	=1 if has dependent children and that they are always or usually the main carer or they are a sole parent; =0 otherwise.	15.6%	5.5%	21.9%
<i>NumChildren</i>	= number of dependent children	0.74 (1.0)	0.76 (1.0)	0.73 (1.0)
<i>LGBTIQ</i>	=1 if identifies as LGBTIQ; = 0 if otherwise.	6.8%	6.6%	6.9%
<i>Racial Minority</i>	=1 if identifies as being Indigenous, Black, Asian or other racial minority; = 0 otherwise	14.7%	15.1%	14.5%
<i>Age ≤ 30</i>	=1 if aged less than or equal to 30 years	4.0%	2.9%	4.7%
<i>Age31-40</i>	=1 if aged 31–40 years	22.8%	20.0%	24.7%
<i>Age41-50</i>	=1 if is aged 41–50 years	30.1%	27.0%	32.0%
<i>Age51+</i>	=1 if is age 51 years or more	42.2%	49.0%	37.9%
<i>Age_miss</i>	=1 if age is missing	0.7%	1.1%	0.5%
<i>STEM</i>	=1 if works within a STEM discipline	47.3%	50.2%	45.5%
<i>Teach_Inc</i>	=1 if time spent on teaching activities (including preparation) increased a little or a lot; =0 otherwise	56.4%	58.6%	55.5%
<i>Teach_na</i>	=1 if deemed the teaching and service question not applicable	27.8%	21.8%	31.5%
<i>Admin_Inc</i>	=1 if time spent on administration and service increased a little or a lot; =0 otherwise	52.8%	48.5%	55.5%
<i>Admin_na</i>	=1 if respondent indicated that the administration and service question was not applicable	3.9%	3.8%	4.0%
<i>WFH</i>	Extent to which respondent worked from home during COVID-19 (=0 if never; = 10 if always). (14 observations with missing information were assigned the mean value)	9.4 (1.7)	9.2 (1.9)	9.4 (1.6)
<i>Clarity</i>	=1 if agreed (somewhat or strongly) with statement that 'It is clear what is expected of me in my job'; = 0 otherwise	58.4%	56.5%	59.4%
<i>Space</i>	=1 if agreed (somewhat or strongly) with statement that 'I have a separate space at home where I can do university work'; = 0 otherwise	68.9%	67.9%	69.6%
<i>Equipment</i>	=1 if agreed (somewhat or strongly) with statement that 'I have good equipment at home'; = 0 otherwise	66.8%	67.7%	66.3%
<i>Support</i>	=1 if agreed (somewhat or strongly) with statement that 'The university provided adequate support to enable me to work at home'; = 0 otherwise	44.0%	40.0%	45.9%
<i>Colleagues</i>	=1 if indicated that connections with colleagues increased a little or a lot as a result of changed working arrangements; =0 otherwise	8.3%	6.6%	9.4%
<i>Disruption</i>	=1 if reported that extent to which working time was disrupted by people increased a little or a lot; =0 otherwise	41.8%	40.0%	43.0%
<i>Australia</i>	=1 if located in Australia; =0 if located in Canada	59.2%	55.4%	61.6%
<i>Flag_wfh</i>	=1 if information on 'WFH' observed	99.8%	99.8%	99.8%
<i>Flag_clarity</i>	=1 if information 'Clarity' observed	99.5%	99.5%	99.5%
<i>Flag_support</i>	=1 if information on 'Support' observed	97.7%	98.1%	97.4%
<i>Flag_disrupt</i>	=1 if information on 'Disruption' observed	98.6%	99.0%	98.4%
Number of Obs		2,817	1,083	1,734

Notes:

1. The means for the binary variables are shown as percentages.
2. The standard deviation for continuous variables is shown in parentheses.