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Unequal effects of the COVID-19 pandemic on researchers: evidence from Chile and Colombia

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The adverse impacts of the COVID-19 pandemic on scientific work and outputs have been a growing global concern after significant and varied effects have been reported in the United States and Europe. Looking to gain insight into the impact of the pandemic in Latin America, we designed and administered an anonymous online survey to researchers based in Chile or Colombia. The survey was implemented in July–August 2020, as the continent was declared the epicentre of COVID-19, and total lockdowns were enacted in both countries. We aimed to understand the overall impact of this situation on research time, exploring unequal effects by discipline and individual characteristics. Results based on 3257 responses indicate that, after accounting by discipline, individual-level differences related to gender and care responsibilities explain the more significant gaps. Specifically, we find that being a woman is linked to higher reductions of time devoted to research, followed by a parenthood penalty for those with children under 12 at home. We also tested a possible relationship between time devoted to research and personal beliefs about gender roles. We found that women who support traditional gender roles and have children reduced their research time more than any other group. Also, men who support progressive views are more impacted than their conservative peers. We conclude that given the heterogeneous impact of the pandemic on researchers, universities and research centres should target specific populations when creating policies aiming to mitigate its effects.

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Introduction

In early 2020, the world entered an unprecedented situation for everyone alive when the spread of a deadly and contagious virus, COVID-19, required societies to stop all nonessential activities to mitigate the effects of a global pandemic. This included the physical closure of university campuses, which generated large-scale disruption for these institutions and their communities. For a small but relevant group of scientists, the disaster meant devoting time and resources to understanding the virus and the impact of the pandemic. This included Latin American researchers, who produced around 3% of the total amount of academic articles related to COVID-19 in 2020, most of them (61.08%) with international collaborations (Torres and Torres, 2021). For most researchers, however, not having access to campus, labs, archives, or subjects meant considerable obstacles to work, especially in terms of research activities (Myers et al., 2020; Gao et al., 2021; King and Frederickson, 2021; Heo et al., 2022; UNESCO, 2021a). Certainly, online teaching demands critical technical and cognitive adaptations for students and professors (Power et al., 2022; Banerjee et al., 2023). However, studies have shown that research is the aspect of academic life more threatened during lockdown since many activities can only be done in the lab or the street, and these locations were no longer available in 2020.

Myers et al. (2020) exposed early on how the pandemic had “undoubtedly disrupted the scientific enterprise” (Myers et al. 2020, p. 880). Based on a survey of Principal Investigators in the United States and Europe, they concluded that 55% of scientists saw a decline in their total working hours. They also reported important changes in the allocation of working time, where research activities suffered the greater change in share of time, a decrease of 24% on average (from 23.63 h average to 17.85). Since Myers et al. (2020) pioneer research, several other studies have evaluated the impact of the pandemic and its subsequent lockdown on researchers, mainly focusing on specific disciplines or fields of study. Overall, this research reports increased workload from online activities, along with decreased research productivity (See, e.g., Ghaffarizadeh et al., 2021; Kruger, Maturana, and Nickerson, 2020; Camerlink et al., 2021; Heo et al., 2022). Most of this evidence, however, has focused on scholars based in the United States or Europe. We lack evidence on the nature and magnitude of the challenges researchers faced elsewhere.

In the case of Latin American countries, there are reasons to believe that the impact of the pandemic and the ensuing lockdown on research activities has been substantial. First, we must consider that Latin American universities are relatively precarious workspaces compared to higher-income countries (Ciocca and Delgado, 2017; Valenzuela-Toro and Viglino, 2021; Silva et al., 2022). Countries in the region invest comparatively few resources in research and innovation, with an average expenditure of 0.66% of GDP, compared to 2.73% for North America and 1.78% for Europe (UNESCO, 2021b). Still, Latin American researchers stand out in certain critical research areas such as astronomy, tsunami science, and climate-related hazards; its researcher’s global connections (40% of articles have international collaborations); and local efforts to create public open science repositories for the 18,000 journals in Spanish or Portuguese that are not captured in global databases. Overall, research in the region was rising fast in publications before the pandemic (Royal Society, 2011; UNESCO, 2021a; Rodrigues and Abadal, 2014). However, the enormous spread of contagion and high mortality rates associated with COVID-19 (Burki, 2020; Rodríguez-Morales et al., 2020; LaRotta et al., 2023) led to extremely long and restrictive lockdowns (Gonzalez et al., 2021). In Chile and Colombia -as in other Latin American countries- university campuses were unavailable all of the 2020 academic year (March

to December) and, in some cases, most of 2021. Lockdowns also meant a lack of access to schools and childcare, affecting parents’ ability to work from home (Augustine et al., 2022; Heo et al., 2022). Furthermore, while most countries in Europe and Asia reported stable funding during the pandemic, Latin American countries reported reduced income for research and higher education spending (UNESCO, 2021a). These factors are believed to have affected the positive pre-pandemic momentum pushing Latin America to increasingly participate in global research production.

To gain insight into the extent of research disruption in the region, we conducted an anonymous online survey of researchers, targeting those based in Chile or Colombia. Even though Brazil is the regional leader in terms of the total amount of publications, its supremacy can be attributed mainly to size. According to reports, Chile, Mexico, Colombia, and Argentina are the regional leaders when controlling for population (Céspedes, 2021; RICyT, 2020). Among this group, we decided to focus on collecting data regarding Chile and Colombia due to their similarities and overall relevance in the region. According to a report (2020) by the Ibero-American and Interamerican Network of Science and Technology Indicators (RICyT, by its Spanish acronym), Chile and Colombia have the fastest-growing scientific production in Latin America, with highly motivated ecosystems. Also, both countries had particularly hard lockdowns, with a minimum of one year of university and school closures for all the territory and strong restrictions to travel internationally and inside the country.

Our research strategy focused on identifying researchers from leading research institutions in each country, collecting 3257 valid responses (see Methods section below). In this article, we use this data to address the following guiding research questions: (a) What was the overall impact of the pandemic on research time among Chilean and Colombian researchers? (b) are there unequal effects at the discipline and individual level? And, finally, (c) is there a relationship between losses on research time and personal beliefs about gender roles? This last question is an innovation from the literature since no research has been found delving into the role of personal gender-role beliefs (i.e., beliefs about gender-specific roles in the household) in mitigating or aggravating the impact of the pandemic on people’s ability to work during lockdown. There is evidence, however, that gender-role beliefs are among the strongest predictors of chore allocation in the household (Kuo et al., 2018; Carreiro, 2021). Literature shows that men with traditional ideas about gender have not significantly increased house labour. Among higher-earning couples, chores may be reallocated to others outside the household, such as hired help and school. Still, outside support was reduced considerably during lockdown, which is believed to have affected women the most (Bastidas, 2021). Furthermore, we must consider that most Latin American countries report more substantial gender inequalities than other Western regions (Bastidas 2021; WEF, 2023). In Chile, the National Time-Use Survey collects information on the different activities of daily life of urban adults. The last version (ENUT, 2015) accounts that women spend five more hours doing unpaid labour than men (2.88 for college-educated women). In Colombia, the same survey shows that women spend 4.38 more hours doing unpaid work than men (ENUT, 2021). Studies made during the pandemic show that the burden of care work increased during lockdown due to the unavailability of schools and other forms of support (Bastidas, 2021). Additionally, literature shows less participation of women in university leadership than in other Western regions. While the number of women in academia has increased in the region during the last decade, achieving 45.8% of the workforce (UNESCO, 2021b), studies show that universities are still very much male-

defined cultures, with significant gender differences in terms of the positions that women hold within universities (Acuna, 2016; Queupil and Muñoz-García, 2019). Overall, Latin American gender inequalities at home and university workspaces may exacerbate the impact of lockdown on female researchers.

The article is organised as follows. After a literature review briefly describing the reported impacts of COVID-19 and its subsequent lockdown on research activities in other countries, we describe our research methods in more detail, including survey design and data collection strategies. We then summarised our main findings organised in two main sections, the first focusing on the individual characteristics of researchers and the second one expanding this analysis to assess the impact of gender-role beliefs. We conclude with a discussion on the limitations of our study, particularly regarding the sampling of researchers, and propose meaningful policy initiatives that could help close the gaps reported.

Time devoted to research: reported disparities

Persistent inequalities in academia are known and well documented, and disasters such as the COVID-19 pandemic are believed to increase existing disparities among groups. For example, in Myers et al. (2020), most scientists declared a decline in their total working hours (55%), but 21% reported spending more time doing research activities during the pandemic than before. Similarly, Aczel et al. (2021) showed that while 58% of researchers found working from home less efficient, about 20% found it more efficient. According to this literature, some differences can be explained at the discipline level, while others respond to individual-level characteristics of researchers.

In terms of disciplinary differences, academics in the “bench sciences,” which require research in laboratories, reported a greater reduction in research hours than those who work in “desk” fields that are less equipment-intensive, such as mathematics or economics (Myers et al., 2020; Ghaffarizadeh et al., 2021). Education, sociology and other social sciences are also more affected than desk disciplines in Myers et al. (2020), probably because of their dependence on access to research sites. The difference between disciplines can be as large as fourfold (Myers et al., 2020). Reports focusing on specific fields support these findings. While in biological sciences researchers reported several challenges and significantly lower productivity (Camerlink et al., 2021), some articles reporting impacts in Economics show a widespread increase in productivity of 35% on average (Kruger et al., 2020). The increase in productivity is partially explained by researchers delving into understanding the economic impact of COVID-19. However, Amano-Patino et al. (2020) have revealed that economists contributing to this new topic are primarily male senior researchers, which shows that inequalities are multiple and not just at the discipline level.

Another essential variable to consider is gender. Research on academia has consistently reported greater obstacles for the 30% of researchers across the world who are women (Fiske, 2012). According to the literature, women in universities face more significant challenges to succeed on different fronts, such as hiring, funding, publications, and promotion, among others (Rivera, 2017; Sato et al., 2021; Tao et al., 2017; Coate and Kandiko, 2016). These multiple disadvantages have led researchers to discuss a “productivity penalty” for women in academia (Wolfinger et al., 2008). The reasons for this penalty are multiple, from organisational culture to bias. The fact that women remain primarily responsible for household activities is one of the most relevant variables explaining the differences in productivity (Misra et al., 2012; Mason et al., 2013). As King et al. have described, a successful academic career often assumes “a

smoothly running care work and support at the home” (2021: 2). But more likely, that is a privilege that not every researcher has, not in regular times, and certainly not during the pandemic. Studies on researchers in Europe and the United States have reported that women have seen their research time disproportionately affected by the conditions imposed by lockdown (Deryugina et al., 2021; Ghaffarizadeh et al., 2021; Morgan et al., 2021). Women’s outcomes have been impacted in terms of article submissions (Wehner et al., 2020), publications (Staniscuaski et al., 2021; King and Frederickson, 2021), grants (Kowal et al., 2020) and well-being (Deryugina et al. 2021).

A significant part of the productivity gap between men and women can be explained by parenthood, or specifically motherhood (Kim and Moser, 2021; Morgan et al., 2021). Literature also uses the term “penalty” to refer to this phenomenon by which women’s careers or job trajectories are slowed down once they become mothers (Sigle-Rushton and Waldfogel, 2007; Correll et al., 2007; Stephen and Correll, 2010; Kahn et al., 2014). Concerning pandemic times, Myers et al. (2020) and several others (King and Frederickson, 2021; Staniscuaski et al., 2021) have shown that the most important variable to explain a decrease in time devoted to research is having a young dependent at home. This is true for all researchers (men and women), but women report greater obstacles to working remotely. This is partially due to the impact that birthing humans have on women’s bodies, but mostly because women remain primarily responsible for child care even among academics (Mason et al., 2013; Misra et al., 2012).

Finally, there is ongoing speculation about the impact of the pandemic on early career researchers who usually have less stable contracts, rendering them more vulnerable to shocks (Harrop et al., 2021; Maas et al., 2020). Only a handful of studies have explored the issue of type of contract, indicating that late-career researchers have remained protected from the worst of the pandemic, labelling them as a group with “minimal impact” regarding the ability to work and do research (Watchorn et al., 2020).

Research design and methods

This study is based on an anonymous online survey of Chilean - and Colombian-based researchers. As mentioned, these countries belong to a group of highly motivated research countries in Latin America (Moiwo and Fulu, 2013; Royal Society, 2011) and had similarly long and hard lockdowns in 2020 (Gonzalez et al., 2021). In both countries, university campuses were closed from March to December 2020, limiting access to workspaces and research equipment. Also, international and domestic travel was heavily restricted, limiting access to fieldwork (international flights resumed in November in the case of Chile and in September in the case of Colombia). Even moving around in your city was highly regulated in Chile and Colombia during this period. In Chile, government imposed measures for those unable to work remotely, including staggered start, end, and lunch hours. In Colombia, the city of Bogotá restricted movement by gender, with men going out on “odd” days and women on “even” days. This was all accompanied by suspending all in-person school classes (K-12) in March, the first month of the school year in both countries.¹ Total lockdowns lasted approximately 22 weeks in each country (from March to September), and our survey was available online for 9 weeks during this time (Mid-July to the first week of October 2020).

Self-reporting online became a common and valuable method for studying behavioural changes during the pandemic (Akin-tunde et al., 2021; Hlatshwako et al., 2021; De Man et al., 2021; de Boni 2020). However, several limitations remain. Access to

websites and internet illiteracy can affect the representability of the sample and induce bias (Eysenbach, 2004). In the case of researchers affiliated with universities, it is reasonable to assume that internet access and literacy are not common obstacles. Still, we must consider that our analysis concludes mainly from self-reported research hours before and after lockdown. Hence, we rely on participants' memory and perceptions during a particularly stressful period, which can be inaccurate (van Hedger et al., 2017). Finally, there is the issue of self-selection of people opting in and the difficulties in evaluating the representativeness of this (non-probabilistic) sample. We have followed Eysenbach's (2004) Checklist for Reporting Results of Internet E-Surveys (CHERRIES) to mitigate these issues. The CHERRIES has been broadly used during the pandemic as a guide for communicating and evaluating the quality of a survey (Singh and Sagar, 2021; Sharma et al., 2021; de Boni 2020). The complete CHERRIES table can be found in the Supplementary Information, but in the next section, we offer a summary of the most important aspects of it.

Target population. We targeted researchers in Chile or Colombia, defined as those working in universities or research centres who hold a graduate degree (master, Ph.D. or equivalent) and report research hours before or during the pandemic. We considered researchers regardless of their type of contract, teaching load, or academic status (assistant, associated, tenured, no-tenure track, or other). This means that, unlike other articles focusing on principal investigators (such as Myers et al., 2020), this study is based on a general survey of researchers in academic settings. We decided against using global repositories such as Scopus or Web of Science (WoS) to identify researchers because most Spanish-speaking journals are not listed in these databases. More than 18,000 journals in these languages are indexed in the public, unrestricted, open science repositories for Iberoamerican research such as Latindex, SciELO, and Redalyc.² But only 18% of Latindex journals are listed in WoS according to Ronda-Pupo (2021), and our own analysis indicates that only 13% are listed in Scopus. Using SciELO for estimating the population of researchers in these countries and accessing authors metadata was not possible at the time since we could not access the catalogue of researchers.³

Considering these limitations, we organised our strategy around institutions. We use international and national rankings that include the research record of universities to identify the leading research universities in each country. The drawback of this approach is that international rankings are driven by publications in global indexes that lack publications in Spanish. Still, national rankings in each country provided significantly similar results. We selected 18 of 86 universities listed by the Colombian Ministry of Education and 31 universities out of the 56 listed by the Chilean *Consejo Nacional de Educación*. While it is true that there are more universities in Colombia, data points out that Chile has more research-oriented universities. In other words, Colombian research activities are much more concentrated at the top research universities than in Chile. Since we selected universities according to their research record, we naturally obtained more Chilean universities to focus on.⁴ We then proceed to collect emails of all researchers in each university from institutional websites. We collected 28,871 emails, 13,876 from Chilean university websites, and 14,995 from Colombian institutions. Still, it must be considered that researchers from other institutions, however small, did answer our survey when they received the link through their networks.

Questionnaire. We used Qualtrics® software to design the survey instrument and collect responses. The questionnaire was

developed by the authors. Explicit authorisation to translate and use certain items from Myers et al. (2020) was obtained from the authors via email. Two of the three items regarding gender-role beliefs were copied from the International Social Survey Programme (ISSP).⁵ A pre-test with Chilean and Colombian scholars was done before the final launch of the survey. The final questionnaire consisted of 46 items. An informed consent was included on the first page of the survey. Both the questionnaire and the protocol were approved by the Institutional Review Board (IRB) for Social Sciences, Arts, and Humanities at P. Universidad Católica de Chile.

Survey administration. Invitations to participate in the study were distributed using Qualtrics © to 28,871 emails. Two follow-up invitations were sent one and two weeks after the first email. We also encouraged respondents to share the survey with their colleagues and research networks, for which we provided an anonymous link. Participants' responses were automatically captured by Qualtrics®, which prevents multiple responses from the same email account. No personal information was collected with the survey. Responses were voluntary, which means that not everyone who completed the survey responded to every item. For more details, see Supplementary Information.

Participation. The survey had 4904 unique visitors, 3489 of them accessing the website after receiving our email and 1415 receiving the link by other means. However, we dropped questionnaires that were answered by researchers residing in other countries. Overall, 4253 people in these two countries agreed to participate in the study by accepting the consent form on the first page, while 3839 people finished the survey. (Note that finishing the survey can involve leaving some items blank.) We considered questionnaires valid when we could confirm that people were researchers. For that, we used the following items: (i) type of institution they worked on (universities or research centres were accepted), (ii) graduate academic degree (masters, Ph.D.s or equivalent were accepted), and (iii) hours devoted to research before or during the pandemic. Additionally, we considered that a questionnaire was analysable when gender was reported. We excluded those identified as "other" since their number could not allow for analysis ($N=12$). If other variables, such as age or graduate level, were missing, the questionnaire was considered valid. Overall, the total number of questionnaires analysed for this article is 3257. The completeness rate (ratio of respondents who answered all the questions used in this article/total of respondents used for this article) is 83.36% (2715). The question with more blanks is age (471), followed by type of contract (34). No statistical correction was performed to weigh the items or adjust the sample. No imputation was performed on the missing data.

Coverage. Since we lack official data on the target population, their numbers, and sociodemographic characteristics, the representativeness of the sample cannot be tested properly.⁶ Still, we can provide an estimate of the coverage of the target population based on the best population data available. According to RICYT (2022), Chile has 15,438 active researchers and Colombia 16,796. In Chile, we collected 1958 valid questionnaires, which indicates a 12.68% coverage. In the case of Colombia, we collected 1299 valid questionnaires, a 7.73% of coverage. Still, these numbers should be taken with caution since RICyTs did not provide the mail list used for this article.

Variables. The *dependent variable* used for this article is the percentage change between weekly hours dedicated to research before and during the pandemic (at the time of the survey). We

Table 1 Summary statistics.

	Mean/Prop.	N
Percentage variation in the research time before and during lockdown	-16.97%	3257
Disciplines		3256
Agriculture, Natural Resources, Forestry	4.36%	
Engineering		
Architecture, Design, Urbanism	5.37%	
Arts (Theatre, Music, Visual Arts)	3.59%	
Astronomy, Astrophysics	0.40%	
Political Sciences	1.57%	
Biological Sciences (Biochemistry, Biology, Others)	7.68%	
Computer's science	2.27%	
Earth Sciences (Geography, Geology)	2.33%	
Communication	2.40%	
Law	3.72%	
Economics	3.44%	
Education, Pedagogy	7.28%	
Nursing	2.70%	
Philosophy, Theology	1.81%	
Physics	2.76%	
History	1.97%	
Engineering (Civil, Industrial, Others)	9.55%	
Literature	2.12%	
Mathematics and Statistics	3.41%	
Medicine	5.47%	
Business and Administration	4.15%	
Other Social Sciences	3.90%	
Other Health Sciences (Dentistry, Kinesiology)	5.50%	
Public or Social Policies	0.98%	
Psychology	5.10%	
Chemistry or Chemical Engineering	3.53%	
Sociology	2.64%	
Respondents' Characteristics		
Colombia	39.91%	3257
Age		2786
<30 years old	2.08%	
30-39 years old	26.06%	
40-49 years old	35.39%	
50-59 years old	22.90%	
60-69 years old	11.38%	
>70 years old	2.19%	
Women	46.82%	3257
Children under 12 years old		3257
None	63.34%	
1 child	21.00%	
2 children	13.02%	
3 children or more	2.64%	
People over 65 years old living in the household		3257
None	83.33%	
1 person	11.11%	
2 people or more	5.56%	
Partner	70.75%	3255
Egalitarianism Index		3186
Very conservative	6.40%	
Conservative	20.21%	
Egalitarian	52.48%	
Very egalitarian	20.90%	
Respondents' Employment Characteristics		
Academic degree		3257
Doctorate	60.39%	
Master	35.09%	
Undergraduate	4.51%	
Academic position		3252
Researcher or Postdoctoral Fellow	3.17%	
Part-Time Professor	16.82%	

Table 1 (continued)

	Mean/Prop.	N
Assistant Professor	47.94%	
Full or Associate Professor	32.07%	
Weekly classes		3257
No teaching current semester	3.72%	
Teaching one class	16.09%	
Teaching two classes	30.43%	
Teaching three classes	26.59%	
Teaching four classes	12.99%	
Teaching five or more classes	10.19%	
Type of contract		3223
Fees or payment per course	9.53%	
Indefinite and fixed-term contract for two years or more	68.79%	
Fixed-term contract for 1 to 2 years	21.69%	

Percentage variation in the research time before and during lockdown. Chile and Colombia, (N = 3257).

constructed this variable using the following items: (i) Hours devoted to research before the pandemic and (ii) Hours devoted to research during the pandemic. In this, we follow Myers et al. (2020) pioneer article on European and U.S.-based researchers. As independent variables, we used sociodemographic questions such as age, gender (46.82% of women), and country of work (39.91% of Colombia and 60.09% of Chile). A total of 27 variables were used for explanatory purposes; a description of the distribution of these variables in our sample is shown in Table 1.

Descriptive analytics allows us to see some of the particularities of researchers in Latin America.

It may surprise some readers that only 60.39% of respondents hold a doctorate. However, it is often not required to have a Ph.D. for teaching or doing research in Latin American universities (RICYT, 2022). Looking into the disciplines, we can see that among STEM (science, technology, engineering, and mathematics), 75.1% of respondents hold a doctorate. In contrast, in HASS (humanities, arts, and social sciences) and MED (medicine and other medical sciences), only 57.8% and 25.2% hold this academic degree, respectively. There are reasons to believe that some MED researchers hold post-graduate medical degrees different than the PhD, but the questionnaire failed to offer this option. There are also minor differences by country, with 63.9% of Chilean respondents and 55.1% of Colombian-based researchers holding a Ph.D.

The precariousness of payment and work conditions in some academic departments in the continent may help explain the presence of professors without a doctorate. Regarding this topic, we coded the broad spectrum of academic titles in both countries into four categories: researcher or postdoctoral fellow, part-time professor, assistant professor, and full or associate professor, with the largest number of respondents being assistant professors (47.94%).⁷

Another important set of variables for this research is household composition. We built four categories for children at home: none (childless), one child, two children, and three children or more, with the majority (63.34%) of academics in our sample reporting no children under 12 years at home, followed by those who report having one (21%). Also, 70.75% of researchers report living with a partner and thus having the possibility to share domestic and care work with another adult at home. Considering the particulars of Latin American culture, we considered the possibility of a second source of care at home: people over 65 (usually retired). It is not surprising that 16.67% of participants declared having at least one elderly person living at home since families in the region tend to be close-knit, often sharing living spaces (Araos and Siles, 2021).

Finally, incorporating variables on gender-role beliefs was an innovation made by this research. For this, we constructed a gender egalitarianism index based on two standard and validated questions developed by the ISSP and a third one developed specially for this study. This index looks to reflect people's beliefs about gender roles within the household, asking them to agree or disagree with the following statements: i) "Having a job is fine, but what most women really want is a home and children"; and ii) "A working mother can establish as warm and solid a relationship with her children as a non-working mother," and iii) "During the pandemic, families must protect the work of those with higher wages." The three items had a five-category Likert scale as a response alternative, ranging from "strongly disagree" to "strongly agree." Those who "strongly disagree" or "disagree" with the most conservative pole were considered egalitarian, and those who responded "strongly agree" and "agree" were considered conservative.⁸ After this, we built a summative index and coded four categories: very conservative, conservative, egalitarian, and very egalitarian. As shown in Table 1, 52.48% of the sample is egalitarian under this definition.

Analyses. We use analysis of variance (ANOVA) and a Bonferroni test to identify statistically significant differences by discipline and individual characteristics of researchers (gender, type of contract, family composition). Then, following Myers et al. (2020), we use Lasso regression to identify which covariables had higher explanatory power over the dependent variable. Selecting which covariates to include in a multivariate regression is notoriously challenging. Still, the Lasso method provides a data-driven approach to this problem by excluding covariates that do not improve the fit of the model. To do so, the method penalises the sum of the absolute values of the regression coefficients (Eq. 1), forcing the coefficients of the predictors to

tend to zero (Lever et al., 2016; James, 2021).

$$\sum_i^n (y_i - \hat{y}_i)^2 + \lambda \sum_j^p |\hat{\beta}_j| = \text{sum squared error} + \lambda \sum_j^p |\hat{\beta}_j| \quad (1)$$

As λ increases, the penalty is greater, and more predictors will be excluded.⁹ Therefore, since the coefficients with a zero value do not affect the model, only the most relevant predictors remain, and these are the ones considered for the final model. In other words, the Lasso regression allows us to identify with greater clarity the attributes most predictive of changes in research time.

Results

According to our data, 54.1% of researchers suffered some decline in time devoted to research during the pandemic. The average researcher used 14.0 weekly hours for research activities before lockdown. At the time of the survey, they were devoting an average of 11.0 h. The total decline in research hours is 16.97%, on average. Still, 24.3% of researchers reported no change, and 21.7% reported increased time devoted to research activities. In the following subsections, we report on the variables that significantly explain these differences, aiming to identify the characteristics of those most affected.

Different disciplines are affected differently. As expected, the pandemic appears to have unevenly affected scientists working in different disciplines. Figure 1 shows the average change in research time by discipline. These discipline level differences are probably due to the nature of research in the different fields, with some areas dependent on laboratories and research facilities—such as astronomy, chemistry, and biology—reporting the largest declines in research time, in the range of 30–50% below pre-pandemic levels. Disciplines that rely on methods that may require face-to-face interaction, such as sociology and

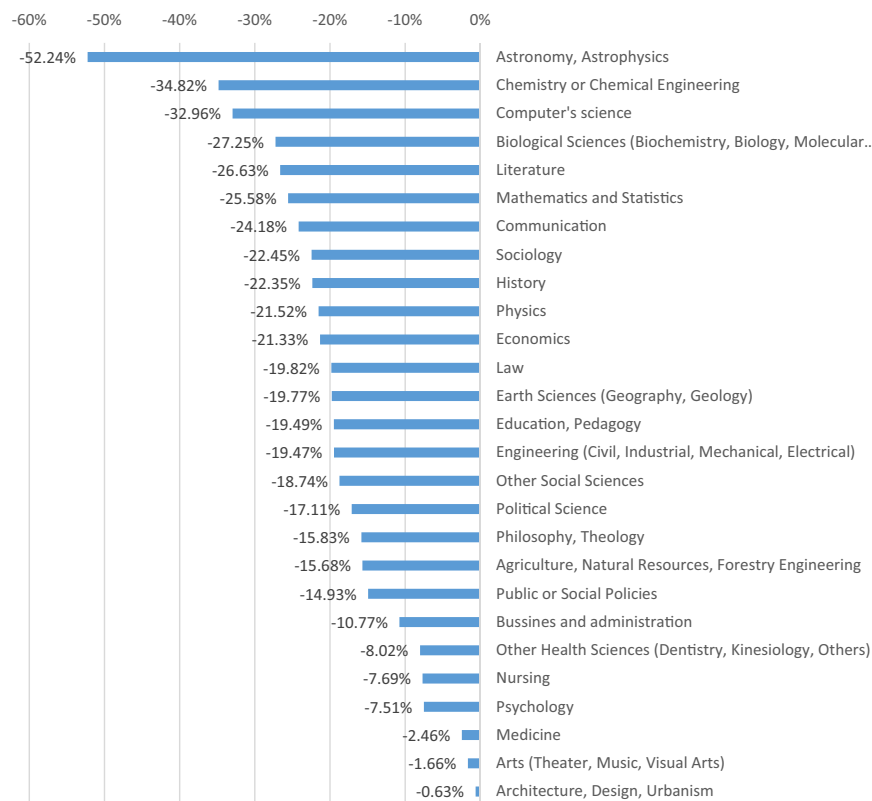


Fig. 1 Discipline-level average changes in research time.

Table 2 Research hours per gender (self-reported).

	N Obs	Decline (%)
Men (all)	1732	−12.42%
Woman (all)	1525	−22.13%
Men (None)	1101	−4.84%
Woman (None)	962	−14.42%
Men (1 Child)	377	−24.65%
Woman (1 Child)	307	−34.49%

communication studies, also rank high in impact. Conversely, health sciences—such as nursing, dentistry, psychology, and medicine—reported the lowest declines in research time. Still, it must be considered that health sciences are among the disciplines with the lowest total hours devoted to research, both before and after the pandemic (see Supplementary Table). Computer science, literature, and mathematics appear surprisingly high in terms of impact, considering their relative independence from labs or research sites.

Women scientists take the toll, especially if there are young dependents at home. Gender also helps explain the variation found in our sample, with female researchers reporting an average 22.13% decline in research time while male researchers reported an average decrease of 12.42% (Table 2). On average, men decreased their research time by 2.49 h, while women reported 3.56 fewer hours for research. This difference is statistically significant.

A critical variable for both groups is having children at home, but the impact is higher for women. As shown in Table 2, women without children experienced less decline in research time (−14.42%) than women researchers with children. Women with at least one child twelve years old or younger experienced a 34.49% decline in research time, and this goes up to a 43.97% decrease when they have three or more children at home.

Figure 2a, b compare male and female researchers. We can see that for every variable, male researchers consistently report less impact on research hours during the pandemic than female researchers. Interestingly, researchers who live with a partner reported a more significant decline in their time for research activities than those without a partner. On the contrary, having one dependent over 65 living at home mitigates the impact on research time for women. This probably indicates that, far from being a burden, sometimes senior family members take a share on house chores and help caring for young dependents. The effect, however, disappears when female researchers have two or more older citizens living at home. The greatest obstacle to allocating hours to research activities during lockdown is having children under 12 at home. For both men and women, having three children at home means a significant reduction in research hours, but in women's case, this goes up to −43.97%. Conversely, male researchers without children are the least affected group (−4.84%, on average).

Finally, it can be noted that academics from Chile show a greater average decline in their research time than Colombian researchers, on average. However, this could be because Chilean researchers reported more time devoted to research before the pandemic.

Teaching or no teaching. The number of classes assigned during the survey is also relevant for understanding changes in research time during the pandemic. No teaching during the pandemic clearly constitutes a relative advantage, especially for female researchers (Fig. 2a), but teaching only one class is still an

advantage if you are a male researcher. People who taught two or more classes during lockdown are consistently more affected than their peers with less teaching load.

Type of contract is not as relevant as expected. To approach the issue of early career scholars, we use three variables: type of contract, academic position, and age, but it is not clear that this group is consistently taking the higher toll. As we can see in Fig. 2a, b (above), assistant professors report greater declines in research time, followed by tenured and full professors. This may be explained by the fact that these groups reported more research hours to begin with. But when we look into type of contract, there is no significant difference between having an indefinite or fix-term contract. In the case of adjuncts -part-time scholars who often receive payments for each class they teach (in the form of fees)- we can see that they are the least affected regarding their research time. This is probably because these positions are not research-oriented, and the total amount of research hours reported by respondents in this category are very low. In the case of postdocs, we can see that the impact is low (for female researchers) or inexistent (in the case of male researchers).

Digging deeper

Changes in research hours reported in the previous sections are informative. Still, we need further analysis to untangle the different factors that help explain a greater decrease in research hours. We use a Lasso regression analysis to identify the impact of the most important discipline- and individual-level characteristics controlled by the other variables. Figure 3 shows the main results of this analysis. Variable names with “female” or “male” suffixes indicate that the variable is interacted with gender; otherwise, the variable describes the average change for all researchers.

Field-level differences continue to be an important explanatory factor, but new distinctions arise. “Bench disciplines” such as astronomy and chemistry continue to show an apparent decline in research hours. In contrast, several disciplines related to health sciences (e.g., medicine, nursing) and arts (including architecture) presented a significant increase in research hours during the pandemic when controlled by individual factors.

When looking at individual-level characteristics, being the parent of child under 12 years of age continues to stand out as the most important explanatory factor for decreased research time. Having three or more children is associated with a decrease in research time of 12.89%, while having no children at home means an average increase in research time of 16.53%. In other words, having no children constituted an advantage for doing more research during the pandemic. Living with a partner and having two or more other adults in the home, continues to be a disadvantage for female researchers. The same can be said for no teaching any class during that semester, or teaching only one class (but only if you are a man).

It is essential to highlight that being a woman means a decrease in research time of 5.35%, even when controlling for all other variables considered. This is also consistent with Myers et al. (2020), who found that female researchers report a 5% larger decline in research time when controlled by other variables. Still, the most important variable is having young children at home. Since Lasso effects are additive, we can say that the most affected group are women aged 40–49 years old, with children under 12 years old and a partner at home. Conversely, the least affected group is men between 50 and 59 years old with no children under 12 at home, teaching no more than one class during lockdown.

None of these findings are surprising considering the literature. Myers et al. (2020) and almost every research project since has found similar results for researchers in the Global North. Unequal divisions of house labour and caregiving between women and



Fig. 2 Group-level average changes in research time, female and male, respectively.

men are well documented, and it is expected to affect how researchers allocate their time during the pandemic. Since Latin America is known to have more traditional gender roles than other Western regions, these results reinforce concerns about the outcomes of women researchers during the pandemic in Chile

and Colombia. Still, not every couple works similarly, and there are reasons to believe that younger generations are changing some of these patterns. With this in mind, we included items related to gender-role beliefs in our questionnaire. The following section explores these results.

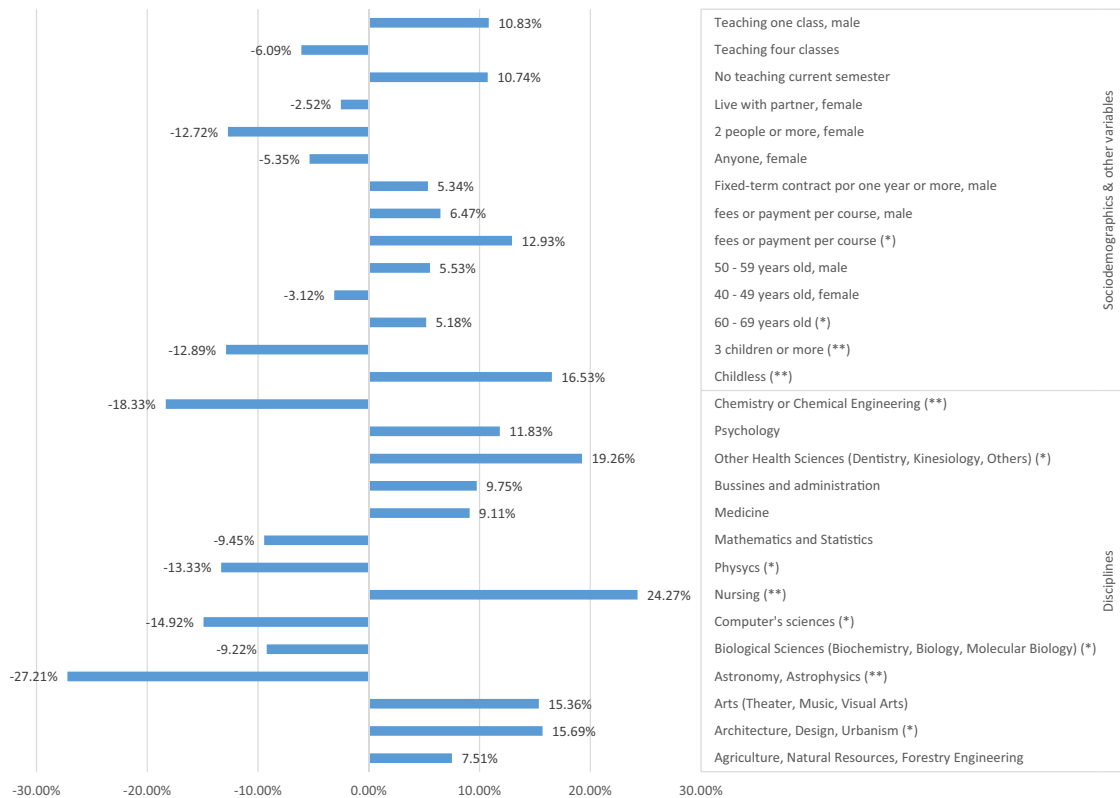


Fig. 3 Changes in research time associated with features of academics or their disciplines after controlling for other factors (Lasso regressions with interactions). Lasso regressions allow us to determine which variables have more power over the dependent variable, but it does not include a significance test. To assess statistical significance a OLS was made using the variables and categories selected by the Lasso regression.

The role of gender-role beliefs

A hypothesis of this study is that culture also plays a role in allocating time during the pandemic. Latino culture is associated with distinct gender roles for men and women, where women have been seen as primarily responsible for housework and childcare. While this is true of many -if not all- cultures, data suggests that Latin America has made relatively slow progress toward gender equality when compared with Europe and North America (Bastidas, 2021; Esteve et al., 2022; WEF, 2023).

In this section, we explore how beliefs about appropriate behaviours for women or men—from more traditional to more egalitarian – partially explain differences in the ability of researchers to maintain their research time during the pandemic. In Fig. 4a, we show the average decrease in research time for each category, showing no statistically significant differences between the groups. Very egalitarian researchers reduced their research time by -20.24%, while very conservative researchers reduced their time by -20.76%. However, when analysing the heterogeneity by gender, significant differences between men and women appear. As we can see in Fig. 4b, “Very conservative” women reduced their research time by -40.35% compared to conservative men, who declined it by -10.07%, on average. At the same time, “very egalitarian” women decreased their research time more than “very egalitarian” men. However, this difference is significantly lower than in the group of more conservative scholars. In this line, it is relevant to point out that egalitarian men had a penalty compared to conservative male researchers. This may be because more egalitarian men tend to share house and care work more equally with their living partners than their conservative peers.

Conclusions

Chilean and Colombian researchers, having fewer hours devoted to research than their European counterparts even in the best of times, reduced their research time to extreme lows during 2020. While researchers in Europe and the United States reported an average of 23.63 h weekly for research activities before the pandemic, the average scholar in our sample reported 14.0 h during regular times. Only 14.15% of researchers in our sample report pre-pandemic research hours above 23.63 h, the mean Myers et al. (2020) reported for researchers in higher-income countries. Apart from the fact that Myers et al. (2020) focused on principal investigators while we collected information from all researchers at different moments of their careers, this difference may be explained by the amount of teaching scholars in the region, with 30.43% of Chilean and Colombian researchers teaching two classes and 49.77% teaching three or more classes at the time of the survey (and still reporting research hours).

During the pandemic, the total decline of research hours in our sample (16.97%) was lower than the 24% estimated by Myers et al. (2020) in Europe and the United States. But in absolute terms, this means that while Colombian and Chilean-based scholars were devoting an average of 11 h to research activities during the pandemic, in Europe and the United States, researchers devoted 14.7 h on average. Conclusively, researchers in higher-income countries devoted more hours to research during the pandemic than Latin American scholars at regular times (on average).

As expected, the impact is unequal among different groups of researchers, and even though there are discipline- and individual-level differences, our results show that the variables that explain the greater differences are related to individual-level differences.

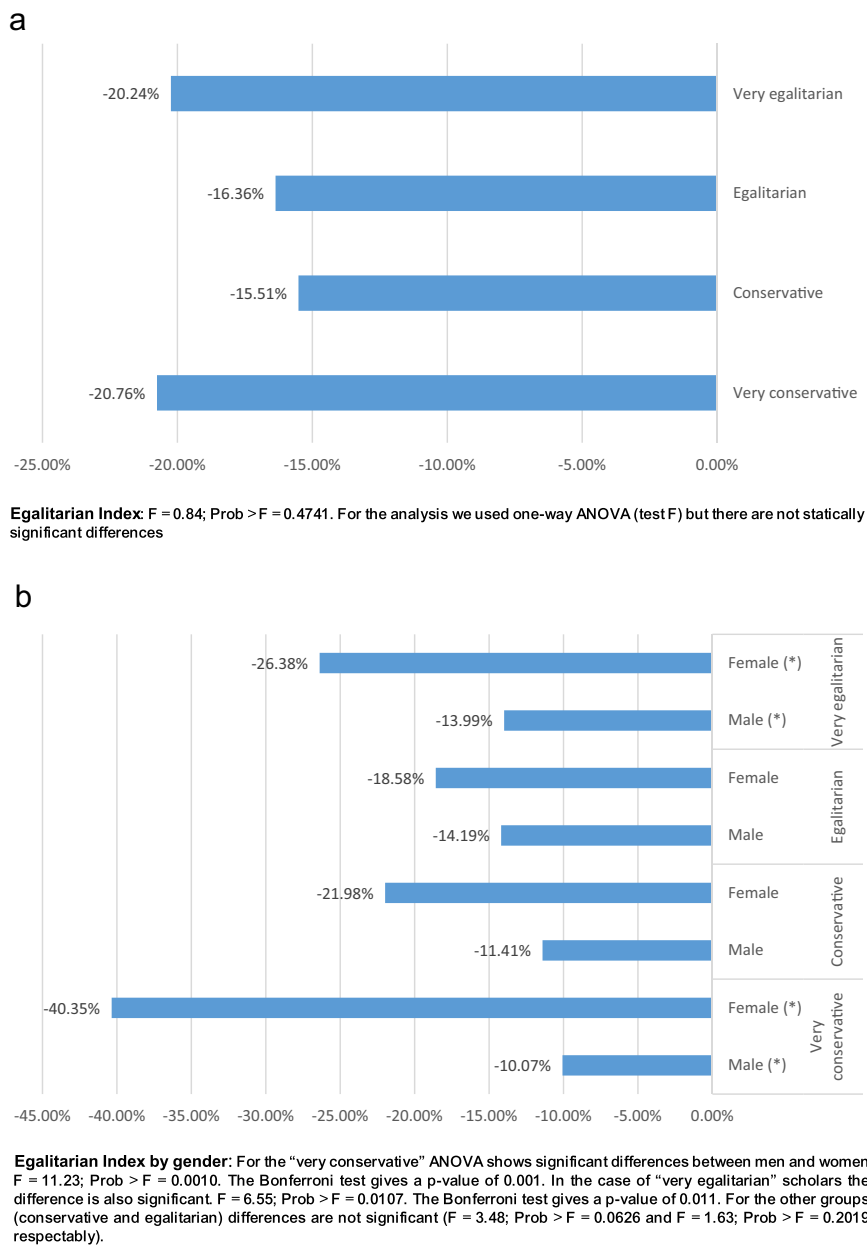


Fig. 4 Egalitarian Index: belief about gender roles. a Research time according to Egalitarian Index ($N = 3186$), **b** Research time according to Egalitarian Index by gender ($N = 3186$).

Discipline and individual characteristics are not fully independent since there is gender segregation by field of study (Supplementary Table). Also, discipline differences are less likely to affect promotions or career prospects since disciplinary culture and practices tend to be similar across countries. All things being equal, women researchers with children under 12 years old were the most affected group in our sample, and the toll for these mothers is larger in our sample than differences reported in higher-income countries (Myers et al., 2020). Probably, this is related to a higher number of households with two or three children under 12 years old at home in Latin American countries. Male researchers with a young dependent at home are the second most affected group, especially if they have egalitarian beliefs. Overall, having children at home during the pandemic is the variable that explains reduced research time the most. Still, incorporating gender role beliefs has proved to be a fruitful innovation. While gender continues to be a

relevant explanatory factor, all else being equal, this research shows that gender role beliefs can impact how time is allocated in households during the pandemic.

Discussion

This article provides important evidence regarding the pandemic’s impact on research activities in two leading Latin American countries: Chile and Colombia. Still, we need further investigations to fully understand how research in the region was affected by COVID-19 and its subsequent lockdown, especially considering that total and intermittent lockdowns expanded in Chile, Colombia, and several other countries way into 2021. Furthermore, while many Western economies improved public spending for science and technology during the COVID-19 pandemic, in Latin America, investment decreased and has not entirely

bounced back (RICYT, 2022). Larger lockdowns and a precarious economic situation will likely mean that the impacts identified by our survey have extended longer than in other regions.

The study has several limitations, posed by the non-probabilistic nature of our sample and the deficient reliability of self-reported research hours during a stressful time. Some of these limitations could be addressed in further research, especially considering new developments in regional and global scientific databases that allow for a better sampling of Latin American researchers (see e.g., De Melo and Costas (2023)). Data collection could also be improved if techniques other than self-reporting retrospectively are included. For example, people could be asked to report real-time- using self-tracking technologies. Still, during lockdown, online surveys were one of the only research methods available for some of the most critical questions posed by the pandemic, and valuable conclusions can be gained from them. The study has allowed us to make visible relevant disparities regarding who could continue with research activities in 2020 and who faced the most challenges to do so. The findings reveal that working from home during total lockdown impacted researchers differently, with certain groups benefiting from even more hours for research activities and others suffering from a sharp decline. Whether this situation will translate into changes in their research outputs (publications, grants, promotions) is an open question we hope to address with further research.

Finally, it must be stressed that these findings have important policy implications for universities and research institutions in the region and beyond. Policy responses such as extensions for tenure, rethinking teaching loads, and special research funds have been discussed at length in different academic forums. It is unclear how many institutions in the region are providing scholars with these opportunities or whether the individual circumstances of researchers are being considered for assigning funds and benefits. This research suggests that it will be advisable to do so. This article, for example, has been partially enabled by a research grant reserved for researchers with care responsibilities during the pandemic. The grant was available for female and male researchers with children, who received funding for an extra research assistant to help with articles such as this one. Overall, the results of our survey point out that targeting policies to specific groups, especially mothers and fathers, could be of great importance in mitigating the impact of shocks on researchers.

Data availability

The datasets generated and analysed during the current study are not publicly available due to UC-Chile Ethics Committee request but are available from the corresponding author upon reasonable request.

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Notes

- 1 Some schools open partially for 1 or 2 days a week in September 2020, but most were closed until March 2021. See UNESCO "Covid-19 Education Response" dashboard available at: <https://covid19.uis.unesco.org/global-monitoring-school-closures-covid19/>.
- 2 Latindex (1997) is the regional information system for scholarly journals from Latin America, the Caribbean, Spain and Portugal (<http://www.latindex.unam.mx/>); SciELO (Scientific Electronic Library Online) was created in 1998 by the Brazilian National Council for Scientific and Technological Development and is the digital library of 16 Latin American countries today (<http://scielo.org>). Redalyc (Red de Revistas Científicas de América Latina y el Caribe, España y Portugal) started in October 2002 by the Universidad Autónoma de México gathers journals published in Spanish, English or Portuguese in 15 Iberoamerican countries (<http://www.redalyc.org>).

- 3 A data dump provided by Scielo in October 2022 has been recently used by Melo et al. (2023) to provide access to this data.
- 4 If we look into the Nature Index, the 10th Colombian university has a 0.36 score, while the 10th Chilean university has a 3.01 score.
- 5 ISSP Research Group (2011): *International Social Survey Programme: ISSP 2012 – Family and Changing Gender Roles IV*: Source questionnaire. The versions in Spanish were copied from Encuesta CEP, with express authorisation from CEP-Chile. Available at: <https://www.cepchile.cl/opinion-publica/encuesta-cep/>.
- 6 In the case of Chile, the Chilean *Servicio de Información de Educación Superior* (SIES) accounts for 11,959 people working full-time as professors in universities and other tertiary education institutions. In the case of Colombia, the *Sistema Nacional de Información de Educación Superior*, accounts for 49,200 people working full-time in universities. However, there is no information on whether their contracts involve research activities or not.
- 7 Full is the Latin American equivalent of tenured, but assistant professor is already a highly stable category.
- 8 For item ii) the recoding is inverse given the phrasing of the statement.
- 9 When λ is zero, it is equivalent to an ordinary least squares model.

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Author contributions

MG and MN conceived the idea for this project. MG and CH designed the study, built the database of participants, developed the questionnaire and collected data. CH, MN, and AC pre-tested the questionnaire. All authors collaboratively discussed methods for analysis. CH and MQ performed empirical analyses. All authors collaboratively interpreted the results. MG led the writing of the manuscript. All authors edited and revised the submitted manuscript, participated in the revisions and approved the final version.

Competing interests

The authors declare no competing interests.

Ethical approval

The questionnaire and methodology for this study were approved by the Humanities and Social Sciences Research Ethics committee at P. Universidad Católica de Chile, UC-Chile; ethics approval number: 200605009. Materials and associated protocols are available to readers upon request (in Spanish).

Informed consent

Informed consent was obtained from all participants. The consent form was signed online on the first page of the survey. Length of time of the survey, time and place of

storage, possible risks and benefits were included in the statement, as well as information about the protocol's IRB approval. An email for questions was provided. No responses were collected from people who did not sign the consent form.

Additional information

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