Gendered Experiences of Software Engineers During the COVID-19 Crisis

Leticia S. Machado and Clara Caldeira, Federal University of Pará

Marcelo Gattermann Perin, Fudanção Getulio Vargas

Cleidson R.B. de Souza, Federal University of Pará

// Although gender divides are largely due to cultural and environmental conditions, changes in the nature of professional and domestic work due to the COVID-19 pandemic have had unprecedented implications on gender inequality.//

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MANDATORY SOCIAL DISTANCING due to the COVID-19 global health crisis in 2020 impacted work arrangements for organizations and workers, created challenges in time management, and constrained transitioning between work and social lives. The transition to mandatory remote work impacted many individuals' personal lives and family dynamics by limiting different services, such as schools, restaurants, and day care facilities. In this context, the social differences influenced by gender roles (i.e., the roles that men and women are expected to occupy based on their sex)[1] may be amplified because of the gendered division of housework and child care tasks, especially for mothers of young children.

Historical inequality between the careers of men and women in many areas is still a reality,[2] including science, technology, engineering, and mathematics. If women's inclusion was already limited beforehand, a disproportional negative impact of the COVID-19 crisis among women stands to harm diversity efforts in the field. Because, in many cultures, the division of labor in housework and child care culturally burdens women at higher rates, the challenges involved in working remotely during a pandemic could lead to higher stress among women, impacting their performance reviews and career advancement. Recently, gender and race gaps in science were observed in the academic productivity of Brazilian scientists during the COVID-19 crisis, as male academics' productivity has been less affected by the pandemic's circumstances than that of women.[3] Ralph et al.[4] argue that the pandemic may disproportionately affect women, parents, and people with disabilities.

In this article, we present the results of an empirical study that explores how the fully remote work arrangement occasioned by COVID-19 affects women

and men differently and examine implications for gender equality efforts. Based on data collected through an online survey conducted in Brazil in the beginning of the social-isolation period, we describe how the impact of working from home on women differ from men's to further explain how the COVID-19 pandemic affects gender inequality.

We find that women face particular challenges during social isolation, as they lack support with housework and child care responsibilities. Further, most strategies adopted by organizations to facilitate working from home (e.g., ergonomic chairs) address men's concerns, but not women's. We discuss these insights in detail and provide concrete recommendations on how organizations can better support women software engineers working remotely, building a more flexible and empathetic workplace during this challenging period and for the long term.

Theoretical Framework

Our study is informed by Olson and Olson's[5,6] framework on distributed collaboration. This framework is based on more than 10 years of experience and describes five major concepts associated with successful remote work: common ground (i.e., mutual understanding among collaborators), the coupling of work (e.g., tightly coupled work is more interdependent, requiring more communication), collaboration readiness (e.g., the motivation to engage in collaboration and proactive communication), collaboration technology readiness (i.e., the effective use of existing technology to accomplish needed tasks),[7] and organization management (e.g., the incentives that facilitate remote collaboration).[8] However, working from home during a pandemic is not like traditional distributed collaboration. Several factors influence the current scenario. For instance, at home, there is the lack of proper physical infrastructure, the need to care for children because schools and day care centers are closed, the fear and anxiety over contracting COVID-19, grief caused by the loss of relatives and friends, and so on. Therefore, we decided to collect information about the impact of interruptions, as working from home requires interruption management.[9,10]

Methods

We collected data through an online survey with 31 questions including demographics, the infrastructure needed to work from home, questions based on each dimension of the Olsons' framework, and interruptions. We also asked respondents about their well-being. In this case, they were given a set of seven choices: anxious, calm, comfortable, uncomfortable, frustrated, worried, relaxed, or any self-reported value. The answers were classified as positive (e.g., calm) or negative (e.g., concerned). From now on, we refer to this variable as simply *well-being* because it will be important for the remainder of the article.

Each one of Olson's concepts was mapped into two or more questions of our survey. For instance, organization management was mapped to a list of strategies and incentives offered by organizations during the pandemic (e.g., a change in the frequency of meetings, flexible working hours, and funding for home-office infrastructure) so that participants could select the ones adopted by their organizations and include new ones. Meanwhile, collaboration readiness prompted participants to indicate how engaged, motivated, available, and proactive their coworkers were. Finally, we asked about the duration and frequency of interruptions because we were also interested in understanding how these interruptions impacted remote work.

For the purposes of data analysis, multiple questions based on a particular concept were each summarized into one single variable validated by structural equation modeling, using statistical software (IBM SPSS)[11] and the maximum likelihood method. The model presented a satisfactory fit ($\chi 2/\mathrm{df} = 2,567$; goodness of fit index = 0.931 comparative fit index = 0.951; and root-mean-square error approximation = 0.066) for common ground, the coupling of work, collaboration readiness, collaboration technology readiness, and interruption level. The organization management variable reflects the sum of the total number of incentives or strategies the participant's organization offered during the social-isolation period.

Data Collection

Our survey was in Portuguese (https://github.com/clarac/distancesurvey/wiki; the English version is available); therefore, we collected data from mostly Brazilian professionals. The survey was conducted through an online platform, and respondents were recruited through shared posts on authors' LinkedIn accounts and direct messages by email (a convenience sample). We also asked informants to share the survey with other potential respondents (snowballing). Because of this process, we were not able to track the total number of invitations.

The survey was open over a five-week period between April and May 2020. During this time there were 401 responses, 366 of which were determined to be valid. We removed answers that did not meet the study criteria (i.e., working from home during the pandemic) and repeated submissions. In this article, we focus on the respondents ($N = 233$) who reported working in computing roles (e.g., software engineer, developer, and product manager) and, due to the focus on gender, the participants who did not disclose their gender are not included in

the analysis. Among the respondents, 84 were women (36.05%) and 149 were men (63.95%). No participants reported a different gender.

Data Analysis

To understand the impact of remote work during social isolation, we conducted two logistic regressions, each including data from one gender. These regressions used well-being as a dependent variable. For the estimations, well-being was applied as a dummy variable that assumed the values of 0 and 1 for negative and positive feelings, respectively. In both regressions, we applied Firth's bias-correction method penalized maximum likelihood that was estimated using *R* and the logistf library.

The regressions included variables representing Olson's theoretical concepts that are known to influence remote work, interruptions, days working remotely, age, and the total number of newly adopted tools (e.g., videoconferencing). Through these analyses, we were able to understand the different factors that impact the well-being of Brazilian women and men working in software engineering careers.

The survey included three open-ended questions asking participants about collaborative tasks, their infrastructure for working from home, and broadly prompting any additional comments. We utilized qualitative methods to analyze these data, comparing the answers provided by men and women to identify differences in their experiences. The first two authors read and annotated the open-ended data, and the findings obtained were discussed and synthesized through meetings with the other authors.

Results

Table 1 presents the logistic regression results. According to this table, the levels of interruption are a significant predictor of well-being for both men and women: a higher number of interruption leads to negative well-being for both genders. In addition, three concepts from the Olsons' framework are also significant, but in different ways: organization management, common ground, and collaboration readiness. Specifically, incentives adopted by organizations (organization management) and common ground do influence men's well-being but do not influence women's. On the other hand, coworkers' collaboration readiness do influence women's well-being but not men's. In other words, the women who ranked worse the collaborative behavior of their coworkers were less likely to report positive well-being.

We also checked possible concentrations of demographic and professional characteristics in the sample for men or women. Chi-square tests were performed to compare gender distribution with regard to schooling level, office distribution, company size, and position. A *t*-test was applied to verify possible differences in company time by gender. None of the tests showed significant differences between men and women.

We also conducted *t*-tests comparing the reported means of each variable tested in the regressions for male and female software engineers. No statistically significant difference was found among the tested variables, which suggests that women and men do not perceive these variables differently, i.e., men and women reported similar levels of interruption, organizational incentives, and so on. What women and men perceive as different is the effect of these variables on their well-being.

We discuss these findings in the following section, along with qualitative insights extracted from open-ended questions, which help to explicate these findings. We classify insights into three categories: interruptions (encompassing both interruptions at home and by coworkers), issues related to working at home (e.g., organizational incentives, private space, and child care responsibilities), and those related to distributed and remote collaboration (e.g., common ground, collaboration readiness, and the coupling of work).

Gendered Interruptions

As mentioned, the interruption level was a significant predictor of well-being for both men and women. Our qualitative analysis reveals that the source of interruption is considerably different for either gender. For example, a female solutions analyst reported "difficulty in managing various tasks (home, children, and appointments) together with isolation and work[ing] from home." Another woman (designer) answered "I had to change the layout of the room for the home office [and] work on the breaks that I take in the middle of the routine for taking care of the child and the house at the same time, which makes me usually work after my kid sleeps, so as not to have interruptions and less stress."

Meanwhile, male respondents shared challenges related to their work space: "I don't have an isolated office in the house. [There is] a lot of noise." Or "it was necessary to reorganize my house so that there is a place for me to work."

In general, our results suggest that interruptions during the social-isolation period are relevant for both men and women. However, women reported being affected by child care needs, homeschooling, and other domestic activities in addition to software development work. In contrast, men reported interruptions associated with infrastructural issues (e.g., noise).

Gendered Experiences of Working at Home

Working from home may involve many challenges related to having a

proper space to work and the presence of family members and housemates as well as personal responsibilities, such as child care and household chores.[9] The organization management variable measures the incentives adopted by organizations to facilitate remote work during social isolation. Surprisingly, incentives did not impact men and women in the same way: Organization management is a significant predictor of well-being for men, but not for women.

Out of the 16 types of incentives in our survey, only three of them could somehow facilitate handling home and child care tasks: flexible working hours, additional days off during the week, and changes in scheduling meetings. However, with the exception of flexible working hours (third-most common for women at 10.98% and second most for men at 12.53%), these incentives were seldom provided to our respondents. In addition, a comparison between men's and women's answers revealed that both received the same types of incentives.

When we analyze other incentives reported by the informants, we find that some reported receiving or borrowing ergonomic chairs or computer equipment from their organizations. Again, this infrastructural aspect was mostly reported by men.

Overall, these results suggest that most organizational incentives addressed men's concerns, but failed to account for women's needs. These incentives disproportionately benefit individuals who are already overrepresented in computing.

Gendered Experiences of Communication With Coworkers

We observed differences in the experiences of men and women regarding their communication with coworkers. Both our statistical analysis and open-ended data illustrate how remote collaboration during COVID-19 impacted men and women differently.

Our quantitative results indicate that collaboration readiness is a significant predictor of well-being for women, i.e., women who reported more collaborative and proactive coworkers were more likely to have positive well-being. However, this was not observed among men. Our qualitative analysis provides a possible explanation for this result. Male respondents described communication challenges due to the lack of informal conversations, i.e., the need to schedule meetings to talk to their colleagues.

Table 1. The quantitative outcomes from our analysis are 1) logistic regression results with factors that predict well-being for men and women software engineers and 2) means and standard deviations per gender.

	Men		Women	
Regression	*B*	exp(B)	*B*	exp(B)
Interruption level	**−0.63**	0.53	**−0.62**	0.54
Organization management	**0.24**	1.27	0.05	1.06
Coupling of work	−0.15	0.86	0.55	1.73
Common ground	**1.22**	0.3	0.88	0.42
Collaboration readiness	0.27	1.31	**1.12**	3.06
Technology readiness	0.13	1.13	0.53	1.7
Number of days working remote	0	1	0.01	1.01
New tools	−0.1	0.9	0.13	1.14
Age	0	0.99	0.05	1.05
t-tests	Mean	Standard deviation	Mean	Standard deviation
Interruption level	2.87	1.3	2.83	1.39
Organization management	3.56	2.12	3.7	2.05
Coupling of work	3.03	0.74	3.11	0.84
Common ground	3.42	0.63	3.88	0.76
Collaboration readiness	4.05	0.7	3.88	0.76
Technology readiness	3.12	0.72	2.98	0.59
Number of days working remote	44.66	24.39	43.39	14.16
New tools	0.86	1.23	1.18	1.36
Age	36.15	7.77	35.04	8.03

The results in bold are statistically significant ($p < 0.05$). No significant differences were found in the individual t-tests that compared the means of each variable among subsamples.

At the same time, they shared that they prefer to minimize interactions to avoid interrupting these colleagues. For instance, a male developer wrote "I try to solve the question by myself before asking my colleagues." A systems analyst shared "I have been trying to disturb my colleagues as little as possible, I always try to understand everything […]"

Meanwhile, women had a different approach; although they also missed the informal conversations, they complained about their colleagues' busy schedules. For instance, a female developer commented "tasks that used to be done through a quick conversation in the hallway, in a person's cubicle, or in a more informal conversation now require finding a time to schedule a meeting." A female deployment analyst reported "we already lacked cooperation among the team members. Now we need to talk using communication tools, the other people can ignore you more easily, and you don't know if (s)he is actually busy."

In addition, we asked about the necessary effort to be understood by colleagues and to handle conflicts (i.e., common ground). Common ground is built through frequent communication and expressing comprehension through words.[7] In our data, men reported a need for more meetings and emails to achieve common ground. For instance, a male software engineer stated, "we now need to have numerous meetings, and in my honest opinion, they are more frequent because of our new work arrangements." Women also expressed frustration with the extra effort needed for common ground. A female technical consultant said "we used to finish tasks faster. Now, anytime I have a tightly coupled task, a scheduled meeting needs to happen. Beforehand, it was enough to turn to the person next to you and talk."

The difference in how men and women experience common ground might explain the reason why achieving common ground was rewarding for men to the point of improving their well-being; however, it had no such effect on women. One woman technology manager said "I manage a team of 36 software developers. If the team faces any barriers, I need to provide support. There are more problems now, so they depend on me more."

Organizational Recommendations

Based on our results, we identify opportunities to better support women software engineers with strategies that promote gender equality. Specifically, we recommend

- flexibility to account for the demands of child care and domestic work. For instance, scheduling that prioritizes parents, particularly women with kids, to better accommodate child care needs.
- scheduling noninterruption periods for focused work. Because women are more exposed to competing demands, they stand to benefit from structured productive time.
- communication policies that allow coworkers to freely ask questions, except during noninterruption periods, to facilitate the flow of information and reduce bottlenecks.
- organizational incentives that reduce the burden of domestic work, such as vouchers for meal delivery, cleaning services or tools (e.g., a robotic vacuum cleaner), and child care.
- regular stand-up meetings or similar brief synchronous sessions to facilitate efficient communication among coworkers and minimize interruptions during the rest of the work day. Holding brief sessions help women to more easily coordinate child care with their partners.
- allowing workers to multitask during meetings by using mobile devices. Women could participate in meetings during other simple activities, such as going for a walk with a child or cooking. We believe that this could facilitate handling conflicting demands.
- carefully accounting for special circumstances when evaluating work performance, as women are likely to have a higher burden of additional work during social-isolation periods.

These recommendations are important not only to support diversity in computing, but also to address communication challenges that are heightened during remote collaboration. Despite often being undervalued by its practitioners, gender diversity benefits workplace social dynamics and productivity.[12] Further, career progression has long been recognized as a problem for at-home workers.[13]

This article reported the different experiences of male and female software engineers during the COVID-19 pandemic. We provided insights and recommendations for organizations to better understand how the new work–family arrangement caused by the pandemic impacts women and men differently and how to better support gender diversity in this and similar contexts. Technology companies need to become more aware of the different responsibilities their employees face because of their gender and adapt quickly to

ABOUT THE AUTHORS

LETICIA S. MACHADO is a postdoctoral researcher at the Federal University of Pará, Belem, Para, 66075-110, Brazil. Her research interests include software engineering, computer-supported cooperative work, and crowdsourcing domains, with applications in understanding the role of collaboration and communication while individuals solve software problems. Machado received her Ph.D. in computer science at the Pontifical Catholic University of Rio Grande do Sul, Brazil. Contact her at leticia.smachado@gmail.com.

MARCELO GATTERMANN PERIN is a professor and researcher at the Fundação Getulio Vargas's Sao Paulo School of Business Administration, Sao Paulo, 01313-902, Brazil. His research interests include the areas of strategic orientations, innovation management, university–industry relations, and sustainability. Perin received his Ph.D. in business administration from the Federal University of Rio Grande do Sul in 2002. Contact him at mperin25@gmail.com.

CLARA CALDEIRA is a postdoctoral researcher at the Federal University of Pará, Belem, Para, 66075-110, Brazil, and an incoming Computing Innovation Fellow at Indiana University Bloomington, Indiana, 47405, USA. Her research in human–computer interaction involves topics such as aging-in-place technology, chronic condition management, cultural and psychosocial aspects of users' experiences, and human–data interaction. Caldeira received her Ph.D. in informatics from the University of California, Irvine. Contact her at claramcaldeira@gmail.com.

CLEIDSON R.B. DE SOUZA is an associate faculty member at the Federal University of Pará, Belem, Para, 66075-110, Brazil. His research interests include understanding how teams of software engineers work together to develop software systems as well as the qualitative and quantitative methods used to achieve this goal. de Souza received his Ph.D. in information and computer sciences from the University of California, Irvine. Contact him at cleidson.desouza@acm.org.

support them so that they can continue benefiting from their work.

Our study has limitations, as expected, and some topics require additional research. For instance, we do not know whether we would have observed similar patterns if software engineers had had more time to prepare for remote work. In addition, our data collection took place after approximately one to two months of remote work. The results could have been different if more time had passed and engineers had already learned how to handle the situation. Finally, the asymmetrical roles of parental child care reported by Brazilian software engineers might not be the case in other cultures.[1]

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