How Do Brazilian Software Development Teams Deal with Working From Home After a Year of the COVID-19 Pandemic?

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ABSTRACT

The COVID-19 pandemic has lasted for over 1 year. During the pandemic, several software development companies migrated to working from home (WFH). Several studies have recorded an initial moment of adaptation to WFH. This study investigated how Brazilian software development teams dealt with WFH after 1 year of a pandemic and how this change in work was on the software development process. We applied a survey with 67 participants of software development teams and investigated aspects, as: work routine, collaboration, communication, productivity, financial assistance and software development process. We performed a quantitative and qualitative analysis of the survey results and compared them with previous studies. Our key findings are: (i) 56.71% of the participants said that it has an impact on the work routine related to work overload and exceeds the company's standard hours; (ii) 92.54% of the participants consider their team to be collaborative; (iii) 82.70% are satisfied with the communication at WFH; (iv) 86.55% has meetings once or twice a day; (v) 59.7% had an improvement in productivity in WFH and 75% are satisfied with their productivity; (vi) 79.60% receive some assistance from the company for WFH; (vii) 82.1% said that the company intends or probably intends to continue in the WFH, and (viii) 55.2% said they had changed in the software development process due to WFH. The main positive changes in the process are related to the practices of: daily meetings, agile processes, code review, pair programming and code versioning.

CCS CONCEPTS

• **Software and its engineering** → **Programming teams**; • **General and reference** → **Empirical studies**.

KEYWORDS

Working from Home, Productivity, Software Development Process.

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1 INTRODUCTION

The COVID-19 pandemic started at the end of 2019 in the city of Wuhan in China and had a global impact. Even after 1 year, the pandemic continues, although several vaccines have already been produced to prevent contagion. In the second wave of high transmission of the virus, the world is considered much more transmissible in countries like India and Brazil due to new variants. According to Who, COVID-19 reached a rate of almost three percent mortality in Brazil from January 3, 2020 to May 9, 2021 [23].

Since March 2020, several software development companies worldwide and in Brazil have strongly adopted working from home (WFH) due to social isolation policies. According to a survey conducted by Gartner on April 3, 2020, about 75% of the CFO's interviewed out of a total of 317 have concluded that at least 5% of their workforce will become remote [12]. Even before the pandemic, remote work has been adopted by several software organizations worldwide [6, 16]. Among the challenges inherent in remote work, distance, culture and collaboration stand out [8]. However, Miller et al. [14] highlights that the regular WFH is not the same as WFH during a pandemic, the COVID-19 pandemic has created a natural experiment for researchers to study WFH on a much larger scale than previously possible.

Several works in the literature have investigated this initial shift of software companies from face-to-face work to the WFH, or hybrid [1, 3, 14, 15, 17, 19]. Most studies investigated the productivity perception during pandemic in software development teams of Brazil [1, 15] and world [14, 17]. According to the studies, several factors can affect the productivity of software development teams at WFH: work environment, communication [1, 14, 15, 17], motivation, camaraderie [14] and team cohesion [1, 14]. Some studies considered the perceived productivity of teams in remote work during the pandemic as good [1, 15] and other studies considered a loss of productivity [14, 17]. However, it is common for the level of social interaction between the participants of the development teams to decrease, especially when it comes to new members in the teams [14, 18]. It is important to note that all the studies cited applied a survey with software development teams from March to August 2020. At that moment, the feeling of the entire world population was that in 2021 the pandemic would end, which did not happen.

In addition to the human and social factors highlighted earlier, it is important to know the impacts of switching to remote work on the software development process. Little has been studied about what changes were needed in the development process to adapt to

this new reality of companies. Most of the students identified in this theme are related to agile methodologies [9, 13, 20]. In addition to the questions of process changes, it is interesting to identify which best practices have been adapted to WFH.

Thus, we aim to investigate the impacts of WFH on Brazilian software development teams after a year of pandemic and what changes were necessary to adapt the software development process to remote work. To guide our study, we elaborated six research questions related to the following factors: work routine, collaboration, communication, productivity, assistance from organizations and software development process. A survey was carried out in April/May 2021 with 67 participants. Our key findings are: (i) 56.71% of the participants said that it has an impact on the work routine related to work overload and exceeds the company's standard hours; (ii) 92.54% of the participants consider their team to be collaborative; (iii) 82.70% are satisfied with the communication at WFH; (iv) 86.55% has meetings once or twice a day; (v) 59.7% had an improvement in productivity in WFH and 75% are satisfied with their productivity; (vi) 79.60% receive some assistance from the company for WFH; (vii) 82.1% said that the company intends or probably intends to continue in the WFH, and (viii) 55.2% said they had changed in the software development process due to WFH. Also, we have identified from the qualitative analysis the most positive changes in the development process, such as: daily meetings, agile processes, code review, pair programming and code versioning.

Moreover, this paper is organized as follows. In Section 2, we present the related work. We present the survey design in Section 3, and results and discussions in Section 4. In Section 5, we present the threats to validity. We conclude with our final remarks and future perspectives in Section 6.

2 RELATED WORK

2.1 Working from Home During the COVID-19 Pandemic

Even before the pandemic, remote work has been adopted by several software development companies in the world [6, 16]. During the pandemic, there was an increase in the number of surveys investigating the WFH of software development teams [1, 14, 15, 17, 18, 21, 22].

Ralph et al. [17] investigated the effects of the pandemic on the wellbeing and productivity of developers. For this, a survey was designed and applied in 12 languages. The data were analyzed using non-parametric inferential statistics and structural equation modeling. The results indicated: the pandemic had a negative effect on the wellbeing and productivity of developers; productivity and wellbeing are closely related; and disaster preparedness, pandemic-related fear, and home office ergonomics affect wellbeing or productivity. The exploratory analysis suggested that: women, parents and people with disabilities may be disproportionately affected; and different people need different types of support.

Bezerra et al. [1] applied a survey to software teams in Brazil to analyze how such factors influence productivity in a remote environment during COVID-19 pandemic. The research identified in the literature human and organizational factors that affect the productivity of software teams, such as: work environment, collaboration and organization of teams, communication, motivation. The main conclusions are: 74.1% of the participants consider that their productivity remains good or excellent, and 84.5% feel motivated and have easy communication with their co-workers. Additionally, the main factors that influence productivity are external interruption, adaptation to the environment and emotional issues.

Oliveira et al. [15] studied the impacts of social isolation on the perceived productivity of Brazilian software developers. The results indicated the perceived productivity of the developers increased, mainly because there are fewer interruptions throughout the day. In addition, the majority of respondents reported that they want to continue working remotely most of the time.

Miller et al. [14] investigated how the team's culture and productivity may also have been affected during the COVID-19 pandemic. Initially, exploratory research during the first months of the pandemic revealed that many developers faced challenges in achieving goals and that team productivity has changed, and with a qualitative analysis, important factors in the team's culture, such as communication and social connection, have been affected. Then, a quantitative analysis of the team's cultural factors that emerged from the first survey was conducted to understand the prevalence of the reported changes. 74% of those interviewed lost social interactions with colleagues and 51% reported a decrease in ease of communication with colleagues. A regression model to identify important factors in the team's culture to model the team's productivity was developed. As a result, the study identified that the ability to brainstorm with colleagues, difficulty communicating with colleagues, and satisfaction with interactions of social activities are important factors associated with the way developers report the productivity of their software development team.

Rodeghero et al. [18] presented a survey of new hires at Microsoft who joined software development teams during the pandemic. It was explored the process of remote integration, challenges that new hires encountered and social connection with teams. As results, most developers never had the opportunity to meet their teammates personally. This leads to a great challenge faced by these new hires, which is to build a strong social connection with your team.

Silveira et al. [21] investigated the impact of COVID-19 on software projects and software development professionals, through a mining software repository study based on 100 GitHub Java projects, and interviews with 279 development professionals to understand the impact of COVID-19 on daily activities and well-being. As a result, 12 observations related to productivity, code quality and well-being were obtained, and it is highlighted that the impact of COVID-19 is not binary (reduce productivity vs. increase productivity), but rather a spectrum, where in many observations, respondents have different opinions from each other.

Sun et al. [22] proposed an automated security and privacy assessment tool (COVIDGUARDIAN) that combines Personal Identification Information (PII), static program analysis and data flow analysis to determine weaknesses in security and privacy. In addition, an user study was carried out to investigate issues related to contact tracing applications. As a result, it is expected that with COVIDGUARDIAN and the issues raised through responsible disclosure to suppliers can contribute to the secure implementation of mobile contact tracing, in addition to the provision of concrete guidelines and highlight gaps between user requirements and the performance of the application.

2.2 Software development process During the COVID-19 Pandemic

Despite several studies focused on productivity and human factors related to WFH during the pandemic, little has been investigated about the impact of WFH on the development process of software companies. We identified in the literature 3 studies related to agile software development practices [9, 13, 20].

The COVID-19 pandemic forced companies to rethink how and where employees work, and how to control them. Schrage [20] presented a literature review using control practices that have been used to control agile or traditional software development teams. Possible adaptations to remote environments for the identified control practices have been developed. 60 control practices have been identified for agile software development, and 36 control practices have been identified for traditional software development teams. Many identified control practices, especially those associated with formal or self-control, can be implemented during the pandemic without adaptation. Although some control practices need to be adapted, others can be emulated through digital services, although the effectiveness is questionable.

The Covid-19 pandemic in 2020 forced Agile Software Development Teams (ASDT) to make a quick transition to remote work and adapt to changing business circumstances. Marek et al. [13] investigated the impact of the Covid-19 pandemic on ASDT work and what tools and metrics are used by ASDT. The results indicated that ASDT's work was not significantly affected, and the majority of ASDT was able to transition to full remote work. The pandemic did not have much impact on the Backlog and product view and most ASDTs did not change their definition of done and release frequency, indicating that the pace and quality of work were not disturbed during the pandemic.

Currently, the predominant mode of execution of Scrum assumes that the team is in the same place, which has changed with the pandemic and the shift to remote work. However, the remote nature of videoconferencing and asynchronous communication brings an overhead never seen before. The result is a weakening of the fundamentals of Scrum in the teams, with modifications being necessary. However, not all changes are positive and a lot of waste has arisen within the teams. Lean principles can be applied to Scrum with minor adjustments and minimal friction. The end result is a variant of Scrum designed with remote teams in mind. Griffin [9] explored challenges that remote teams are facing, the proposed modifications and the result of these changes in a remote software engineering team.

3 SURVEY RESEARCH DESIGN

Our study aims to analyze the impacts of WFH on Brazilian software development teams and changes in the software development process after 1 year of the COVID-19 pandemic. For this, we have prepared a survey based on previous studies that investigate WFH at the beginning of the pandemic [1, 15, 17].

3.1 Research Questions

We have elaborated the following research questions to guide our study:

$\boldsymbol{RQ_1}$ – *How does WFH impact the work routine of software development teams?* This issue is related to the impacts of WFH on the work routine of software development teams. The impacts on the routine are related to the company's workload and standard working hours. It is also investigated what is the work regime of the teams before and during the COVID-19 pandemic.

$\boldsymbol{RQ_2}$ – *How satisfied are the software development teams' collaboration at WFH?* In this research question, we asked the participants if the development teams are collaborative. Collaboration is an important point for better WFH productivity. In addition, collaboration can positively influence factors such as communication and improving the team's well-being.

$\boldsymbol{RQ_3}$ – *How is the development team communicating during WFH?* Communication is one of the most affected factors in the transition to WFH. We want to know from the teams how remote communication is carried out, indicating which tools and satisfaction with remote communication. In addition, we ask how many times teams meet on projects to find out if the number of meetings has increased or decreased in WFH. Communication is a factor that influences team productivity and also how the software development process is carried out.

$\boldsymbol{RQ_4}$ – *How do software development teams evaluate their productivity in the WFH?* In this question, we analyzed the productivity perception of the software development teams at WFH. Several studies have analyzed the perceived productivity of teams at an early stage of the pandemic [1, 14, 15, 17]. However, we want to know if, after 1 year of the pandemic, the perception of productivity remains the same. The fact that teams are productive in WFH can influence the decision of organizations to continue adhering to remote work even after the pandemic.

$\boldsymbol{RQ_5}$ – *How do software companies assist software development teams at WFH?* This question aims to investigate whether companies are assisting their employees with financial aid or equipment for WFH. The equipment provided by the company is detailed, and we also asked the employees how companies could further assist them in remote work. In addition, we also investigate whether organizations intend to continue on the WFH work regime or a hybrid regime.

$\boldsymbol{RQ_6}$ – *What is the impact of WFH on the software development process?* - In this question, we want to investigate if there were changes in the software development process due to the change to WFH. In case of changes, we qualitatively investigate the main changes in the process and which changes had a positive and negative impact on the productivity of the software development teams. These changes can guide other organizations to adhere to good practices in the software development process adapted positively to WFH.

3.2 Population

The survey population was composed of people who work with software development from Brazilian companies. We disseminate the research on discussion lists and IT social networks for the self-recruitment of participants. We also sent IT professionals from several states so that the five regions of Brazil could participate.

3.3 Instrument Design

Our survey was built based on previous studies evaluating WFH at the beginning of the pandemic [1, 15, 17]. These studies investigated the perceived productivity of development teams in Brazil and worldwide. However, in addition to productivity, we would like to analyze: (i) the current situation of the development teams in the WFH after a year of the pandemic, (ii) if the organizations intend to adopt the WFH after the pandemic, and (iii) what are the impacts changes in the software development process due to adaptation to WFH. To guide our study, we defined the research questions based on 6 factors: work routine, collaboration, communication, productivity, company assistance and software development process. For each research question, subquestions were defined grouped to these factors, in addition to the profile of the participants. Our survey was anonymous, and no personally identifiable information was collected. The research anonymity creates a more open and honest space for research participants [10]. Besides, before participating in the research, the participants accepted the research disclosure and publication terms.

We validated the survey pilot with 2 researchers from the study and 3 representatives from software development teams. The survey was refined according to the requested changes, and previous responses were discarded. Table 1 presents all survey questions identified by an ID and divided by categories to be analyzed to answer the research questions.

3.4 Data Analysis

Surveys collect qualitative and quantitative information to provide a snapshot of the current status related to a phenomenon [24]. In quantitative analysis, we use descriptive statistics, for example, to represent and describe the participants' characterization data. We also use the Business Intelligence (BI) technique for better manipulation and analysis of quantitative data. For this, we created a website with all consolidated data divided by research questions using Power BI[1]. Survey data is available for study replication[2].

The qualitative analysis was inspired by the procedures presented by [7]. In this analysis, we used procedures from the Grounded Theory (GT) [5] methodology. GT aims to create a theory from the data collected and analyzed systematically, consisting of three phases: (1) open coding, (2) axial coding and (3) selective coding. In open coding, a break, analysis, comparison, conceptualization and data categorization is performed [5]. In axial coding, categories are associated with their subcategories, forming more related and dense categories. Finally, in selective coding, the central category or the study's idea is identified, corresponding to the theory in which all categories are related. Strauss and Corbin explain that the researcher can use only a few steps to achieve his research goal [5]. So, in this research, we used only the GT's phases 1 and 2 to identify the categories and their relationships. Additionally, another researcher reviewed the analysis to avoid trends.

Some quotes from the participants were captured to highlight aspects of opinion issues. These participants are identified in the survey with the following nomenclature to preserve anonymity: capital letter "P" followed by a number corresponding to the survey's response sequence.

Table 1: Survey

ID	Questions
	Profile
Q1	In which region do you work? (North, Northeast, Midwest, South, Southeast)
Q2	What region is your company located in? (North, Northeast, Midwest, South, Southeast)
Q3	What is your role in software projects? (Project Manager, Developer, etc.)
Q4	How much experience do you have in this role? (< 5 years, 5-10 years, > 10 years)
Q5	How many people make up your project team? (0-20, 21-40, 41-60, 61-80, More than 81)
	RQ_1: Work routine
Q6	Before the pandemic, what was your modality of work? (Full-time attendance, Hybrid, Home office)
Q7	During the pandemic, what is your modality of work? (Full-time attendance, Hybrid, Home office)
Q8	What is your work routine like during the WFH? (Sometimes I exceed the company's workload, Generally exceeds the company's regular working hours, etc.)
	RQ_2: Collaboration between team members
Q9	How satisfied are you with the collaboration of your team during the WFH? (unsatisfied 1 - 5 very satisfied)
	RQ_3: Communication between team members
Q10	What are the most used communication channels during the WFH? (Video conference meetings, Emails, Chat apps (Whatsapp, Telegram), File sharing, etc.)
Q11	What tools are used to conduct remote meetings? (Google Meet, Zoom.us, Slack, Whatsapp, etc.)
Q12	Have there been changes in communication channels in the projects? (yes/no)
Q13	How many times did your team meet to discuss issues of project during the WFH? (Twice a day, Once a day, Once a week, etc.)
Q14	How do you evaluate the communication used by your team during the WFH? (unsatisfied 1 - 5 very satisfied)
	RQ_4: Productivity's perception
Q15	Did you feel better work productivity during the WFH? (yes/no)
Q16	How do you evaluate your productivity during the WFH? (unsatisfied 1 - 5 very satisfied)
	RQ_5: Assistance and perception of companies
Q17	Does the company you work for intend to continue with the remote work after the COVID-19 pandemic? (yes,no,probaly,dont know)
Q18	Did your company provide any kind of financial or material help? (payment of the Internet, notebook, monitors, etc.)
	RQ_6: Software development process
Q19	Have there been changes in the development process during the WFH? (yes/no)
Q20	What changes occurred in the software development process of your project during the WFH??
Q21	What software development practices used in your area do you consider that had a positive impact on your productivity during the WFH?
Q22	What software development practices used in your area of activity do you consider that had a negative impact on your productivity during the WFH?

4 RESULTS AND DISCUSSION

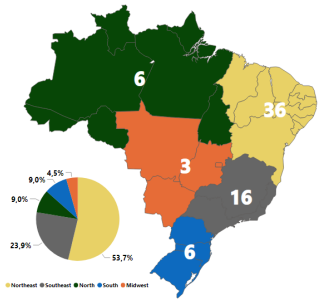
4.1 Profile

Our survey was made available from 28 April to 12 May 2021, in several lists and groups of IT professionals in Brazil. There were 71 participants, 4 of them did not meet the validation criteria, because they did not fit the profile of software teams. Thus, we consider only the 67 participants' answers. Table 1 presents all survey questions. All survey data are available anonymously on the website[3].In this section we analyze some aspects regarding the research participants' profile.

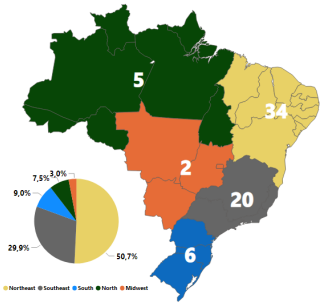
Initially, we asked the participants what region he lives in (Q1) and in which region the company he works for is located (Q2), as illustrated in Figure 1 (a) and 1 (b) respectively. Most of the participants in our survey live in the Northeast (53.7%) or Southeast (23.9%). Regarding the company's location, the percentage of the Northeast decreased slightly (50.75%) and the percentage of the

[1]https://powerbi.microsoft.com/pt-br/desktop/
[2]https://github.com/amarildobarros/SBES_WFH_2021
[3]http://bit.ly/RwSurvey

Southeast increased (29.85%) to the location of the participants. That is to say, that part of the participants do not work in companies located in their region, which is more and more common in WFH.



(a) Participants



(b) Companies

Figure 1: Participants and companies distribution across Brazilian regions.

Regarding the participant's role in the company (Q3), most participants were developers (39.02%) or test analysts (13.41%), as we can see in Figure 2. In addition, other roles on the development team were highlighted. The level of experience of the participants was also asked (Q4), and the majority answered that they have experience of up to 3 years (37.31%) and between 3 and 5 years (35.82%), followed by between 5 and 10 years (17.91%) and more than 10 years (8.96%). We can see that most participants have little experience, and that can be mostly young. Finally, he was asked how many people have the project team (Q5). Most responded that the team size is between 1 to 25 people (77.61%), followed by the size between 25 to 50 people (17.91%), which leads us to conclude that most participants work in small teams.

Compared to other studies in the literature [14, 17, 18], our sample was small. There is a difficulty for people working in the industry to interact with the academy. We believe that if companies ask their employees to respond, participation would be greater. However, we try to cover all regions of Brazil.

4.2 RQ_1: Work Routine

RQ_1 is related to the work regime before and during the pandemic and the impact that WFH has on the teams' work routine. Questions Q6 and Q7 are related to work regime before and during the pandemic, respectively, as shown in Figure 3. We can analyze that

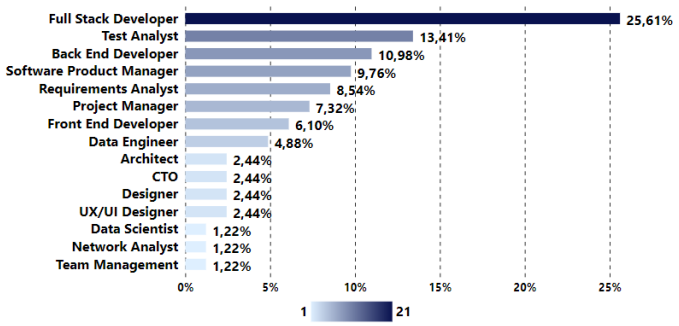


Figure 2: Participants distribution by roles in software teams

many participants (64.2%) had a full-time attendance work regime before the pandemic. During the pandemic, the work regime shifted mostly to the home office (86.6%) and hybrid (13.4%). This information helps us to understand the impact on the work routine of the participants in this research.

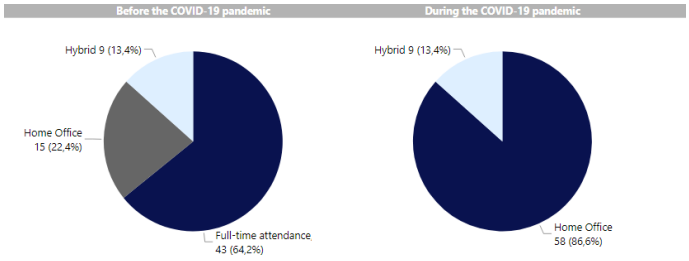


Figure 3: Work regime before and during the COVID-19 pandemic

Q8 investigates the impact on the work routine regarding the company's workload and standard hours. We want to investigate whether there is a greater work overload in WFH and whether teams often exceed the company's standard business hours. Depending on the responses of the participants, we can see in Figure 4, that most participants indicated that they usually (18) or sometimes (20) exceed standard working hours (56.71%). It was also indicated that most research participants always (10), generally (11) or sometimes (17) exceed the workload (56.71%). With these results, we can conclude that WFH impacts the work routine of Brazilian software development teams.

Bezerra et al. [1] indicated in their study that a large percentage of participants who work in development teams do not maintain a routine at WFH. Research participants indicated that the impacts on the work routine were due to: increased work, domestic activities, psychological state, insomnia and having small children. Our study found that the impact exceeds both the workload and the standard time of the software company.

4.3 RQ_2: Collaboration between Team Members

Collaboration between team members is a factor that positively influences productivity [2]. We analyzed this factor in question Q9, asking participants to evaluate their team's collaboration on a scale

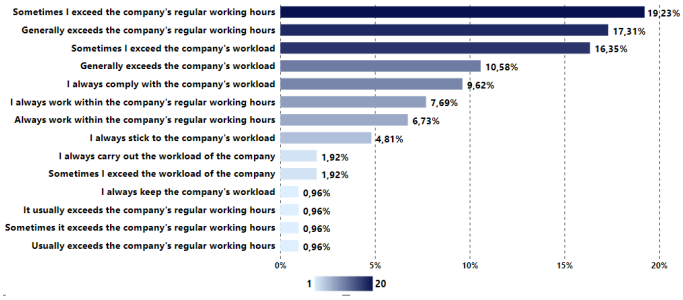


Figure 4: Participants' work routine

ranging from 1 (unsatisfied) to 5 (very satisfied). For the analysis, we consider that responses in the 4-5 range represent collaborative teams, while those in the 1-3 range represent teams with low levels of collaboration. Of the 67 participants, 62 (92.54%) consider their team to be collaborative (see Figure 5).

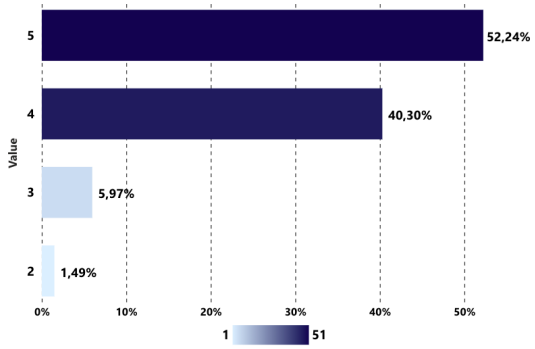


Figure 5: Satisfaction level with the collaboration of the teams

We realized that even in the remote format, the collaboration of the software development teams was not affected. When we compared this result with previous work at the beginning of the pandemic, we found that the teams were also collaborative [1]. However, according to Miller et al. [14] and Rodeghero et al. [18], several challenges inherent to collaboration were perceived, such as: camera on, difficulty in conducting brainstorming, communication in the first two weeks of work and insufficient communication. Collaboration is a key point for improving communication and consequently productivity. Besides, it can influence WFH's well-being and satisfaction.

4.4 RQ_3: Communication between Team Members

It is known that remote communication has even more challenges considering the productivity of software companies [25]. Thus, they have invested in robust tools to facilitate remote communication (e.g. video conference meetings, chat apps, and file sharing) [11]. Ease of communication usually has a positive influence on software development productivity [4]. Elements related to the communication infrastructure and the company's work environment also influence communication facilities and other factors already reported (e.g., team cohesion and collaborative work) [4].

In the survey, we asked the participants the most used communication channels (Q10), obtaining the following results with the number of mentions of the participants: videoconference (64), messages apps (58), email (43) and intranet (11). We also asked which are the main communication tools used (Q11). Figure 6 presents the tools most used by the research participants. We can highlight the tools: Google meet, Microsoft Teams, Whatsapp, Slack and Zoom.us.

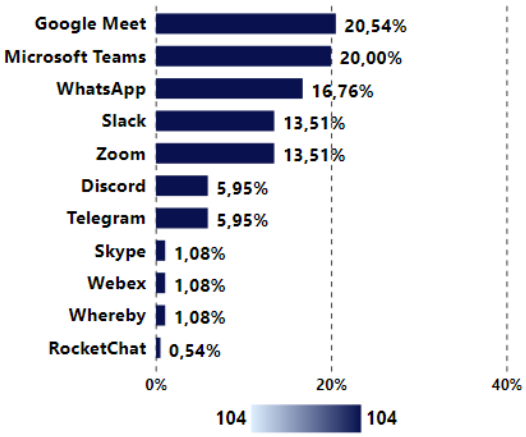


Figure 6: Tools used in remote communication

Still in the communication factor, we asked the participants if there was a change in communication in the projects due to the WFH (Q12) and 64% of the participants said yes. Some participants (36%) said that they did not, since they already worked in a remote or hybrid format before the pandemic. We also asked how often meetings took place in the projects (Q13). We can see in Figure 7 that most participants replied that they participate in meetings once a day (58.20%) or twice a day (28.35%). Finally, in Q14 we checked the satisfaction with the communication at WFH. We considered the 4-5 scale to have a good satisfaction with remote communication. Most participants (82.70%) replied that they were satisfied with the communication at WFH, despite the high number of meetings.

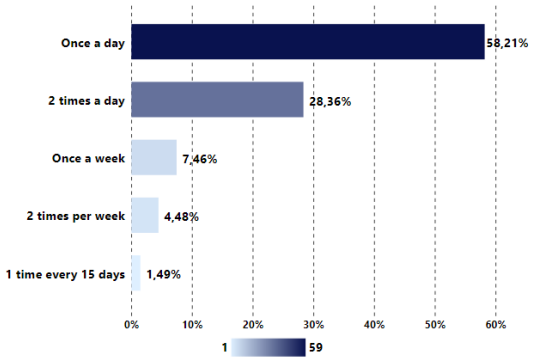


Figure 7: Frequency of meetings at WFH

Similar to the studies of Oliveira et al. [15] and Bezerra et al. [1], we identified the same set of tools used. However, in our study, there were more mentions of the Microsoft Teams tool, which was also the tool that was highlighted in recent studies [14, 18]. Probably due to the acquisition of corporate tools paid for during the pandemic. Bezerra et al. [1] also highlighted the ease of communication of most study participants, corroborating our findings. Oliveira et al. [15] and Miller et al. [14] also highlighted in the same way in our study the increase in the number of meetings at the beginning of the pandemic.

4.5 RQ_4: Productivity Perception

In the survey, we asked what the perception of productivity improvement in WFH during the COVID-19 pandemic (Q15), where 59.7% of the participants answered yes, productivity improved in WFH. In addition, we asked participants how they assess satisfaction with their productivity in the same period (Q16). We used the Likert scale for this question, where (1) it represented unsatisfied and (5) it represented very satisfied, considering the school 4-5 as satisfied. In Figure 8 we can see that almost 75% of the participants are satisfied with their productivity during the execution of their activities in the year WFH after one year of the pandemic COVID-19.

The results found related to the perception of productivity are similar to the studies of productivity of Brazilian software teams of Oliveira et al. [15] and Bezerra et al. [1], where the authors identified that more than 70% of the study participants reported good productivity in the pandemic in the WFH. However, in studies with software teams in other countries, a reduction in productivity was identified in the WFH [14, 17].

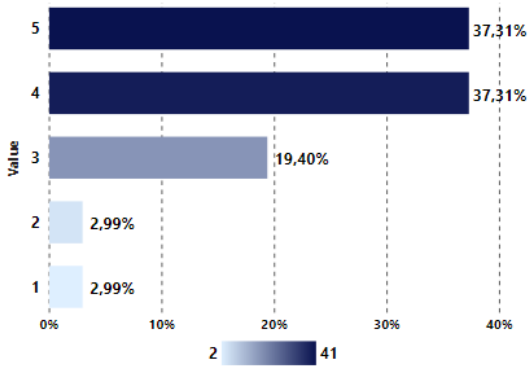


Figure 8: Productivity perception of software development teams

4.6 RQ_5: Assistance and Perception of Companies

Aiming to get more information about software development companies watched their employees in WFH, we asked the participants if the company they work for provided some assistance (Q18). Most respondents indicated that the company provided the following types of assistance, as shown in Figure 9: notebook (40), headset (28), mouse and keyboard (28), monitor (27), equipment ergonomic (23), professional courses (17), financial assistance (16), residential internet (14), psychological assistance (9) and certifications (7). Only 13 participants (19.40%) indicated that they do not receive any assistance for the WFH. These data show concern of most companies with their employees' work environment.

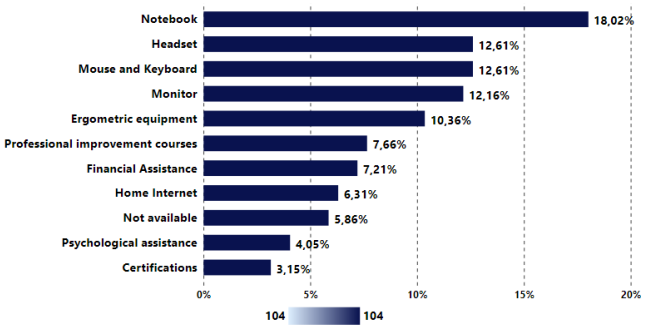


Figure 9: Company assistance for WFH

We also asked if the participants' work intends to continue with the WFH modality after the pandemic COVID-19 (Q17). Most participants answered yes (40), intend to continue in the WFH or probably (15), corresponding to 82.1% of participants. These results confirm our intuition that companies have successfully adopted WFH, and the pandemic has only shown that it is possible to work in a remote format.

4.7 RQ_6: Software Development Process

RQ_6 investigates changes related to WFH in the software development process and what are the positive and negative changes. Initially, we asked the participants if there were changes in the software development process at WFH (Q19), and 55.2 % answered that there were changes. Based on this information, we investigate the changes in the software development process in a qualitative way. Questions Q20, Q21 and Q22 were analyzed using GT. In this work, 10 categories were identified, arranged below in decreasing order of citations in the responses: Development (64), Monitoring (48), Communication (31), Tool (20), Time (18), Engagement (14), Work Environment (12), Planning (9) e Social Interaction (6). Table 2 describes each of these categories.

Table 2: Description of the categories identified in the qualitative analysis

Category	Description
Monitoring	Meetings, ways of monitoring the project
Work Environment	Workplace, activities at home, private infrastructure, working conditions
Communication	Types of communication, synchronous, asynchronous, general, inter and extra team
Development	Releases, products, processes, documentation
Engagement	Involvement of the team or stakeholders, dedication, focus on project activities, distractions, obligations and responsibilities
Tool	Tools or platforms used for the most diverse purposes in the projec
Social Interaction	Non-work conversations, socializing
Planning	Actions for planning and replanning project items, organizing activities
Time	Time spent on activities, increasing or reducing time, deadlines and schedules

Figures 10, 11 and 12 show the categories and relationships identified for the changes, positive points and negative points, respectively.

4.7.1 Changes. For the changes, the following categories were identified: Monitoring, Communication, Development, Engagement, Tools, Social Interaction and Time. Figure 10 shows these categories and relationships.

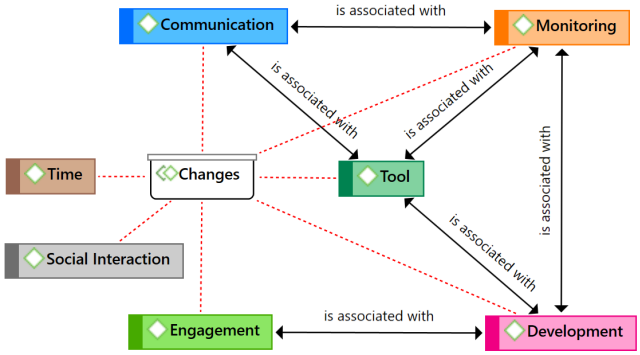


Figure 10: Categories and relationships identified for Q20

Many relationships emerged from the Monitoring category, with emphasis on Communication, Development and Tools. In relation to Communication, mentions about contacts for transferring content, as in the commentary of **P65** with "*Constant contacts and some meetings to pass on models of processes and documentation for the dissemination of knowledge*". There were also citations about changes in the form of development due to the form of communication, as in the speech of **P19** with "*One of the changes was the way of communicating and the way of developing some parts of the project*". Communication has changed a lot because of new tools, and this has also impacted processes and activities, mainly in the way of following projects as highlighted by **P32** in "*The team's communication had to be expanded through application Communication*".

Communication associated with tools in this work style had an impact on projects, often due to the number of tools evaluated to find the most suitable, highlighted by **P39** with "*The first change was the communication channel, we used Teams first but in our case we followed Discord, our project organization tools were closer to the code, as we started using the gitlab board*".

The engagement associated with development was also perceived by the developers, often due to their greater participation in the planning and definition of releases, mentioned by **P57** with "*Engagement of the dev team in product and timeline definitions*".

And as development is always supported by tools, the more massive adoption of tools for a better adaptation of the work to the remote model is natural, as mentioned by **P3** in "*The fact of using Microsoft teams and several work tools that involve not only online courses but programs that improve productivity, for example, Jira to manage our sprints and time spent on the project*".

In general, the meetings were the most mentioned process activities about development. Many answers indicated an increase in the number of meetings. Monitoring in general was also mentioned a lot, generally as a form of closer communication and also related to tools and meetings. With regard to tools, the impact of fully adapting to the needs was perceived, as some had to be tried and exchanged in order to be fully adopted, having an impact on development. Finally, time related to schedules, deadlines and management was also cited as impacted due to the need to adapt to the remote model. Our results corroborate with the study of Oliveira et al. [15], where it was reported that of the changes that occurred in the development process, the majority were in meetings (64.57%), followed by formal communication (13.90%) and tools (3.14%).

4.7.2 Positives. For the positive points, the following categories were identified: Monitoring, Work Environment, Communication, Development, Engagement, Tool, Social Interaction, Planning and Time. Figure 11 presents these categories and relationships.

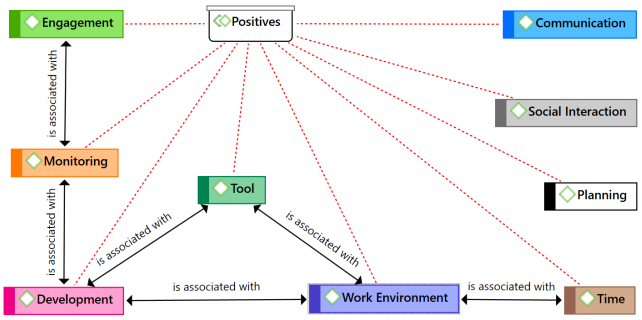


Figure 11: Categories and relationships identified for Q21

Monitoring was mentioned on several levels as a positive point. Regarding the engagement of activities and the execution of online meetings, it was commented by **P29** "*Requirements analysis was more productive because no face-to-face meetings are needed*". This was shown by some respondents as a motivation, generating greater engagement in the project activities, cited by **P30** with "*Daily meetings to find out how the project activities are and to understand the team / help*".

The Work Environment category had several relationships and mentions. As for development, the impact is direct, often beneficial, as mentioned by **P18** with "*Otherwise, the production was much more comfortable to carry out since the tension in the work environment it was removed and even with family members at home and everyday tasks, it is still possible to develop a good job and thanks to this comfort, production time can be extended, that is, jobs go faster*". Working from home can be comfortable, as described in the comment by **P43** with "*Not relying on anything but a computer and the internet as the main work tools is certainly a factor that makes our development area perfect for the home office*". However, to be beneficial, the infrastructure and tools must be adequate for the full execution of the work, The time spent in the work environment was also mentioned, and it can be beneficial if well managed. In the speech of *P22* this impact was clear: "*More time at home impacted having more time to work outside normal hours*".

Development associated with tools is natural. And analyzing the answers, there was a benefit in conducting the project, as in the comments of **P20** with "*More effective communication and the shared use of tools to support the software development cycle*" and

P39 in "*Bring project management closer to the code, for example: use the management tools of the code versioning platforms*".

Table 3 lists the positive practices of the software development process identified in the respondents' speeches. The value indicates the number of times that each of the practices was mentioned. Highlight for the good practice of meetings, often for practicality, ease and communication, and use of version control and code review tools.

Table 3: Positive practices in the software process

Positive practices in the software development process	Quantity
Daily meetings	7
Agile development, Code review, SCRUM	5
Code versioning	4
Pair programming	3
Frequent tests, Kanban, Pair review	2
Continuous integration, Daily deliveries, Metrics collection, Requirements analysis, Retrospective meeting, Review meeting, Sprint planning	1

4.7.3 Negatives. For the negative points, the following categories were identified: Monitoring, Work Environment, Communication, Development, Engagement, Tool, Social Interaction, Planning and Time. Figure 12 presents these categories and relationships.

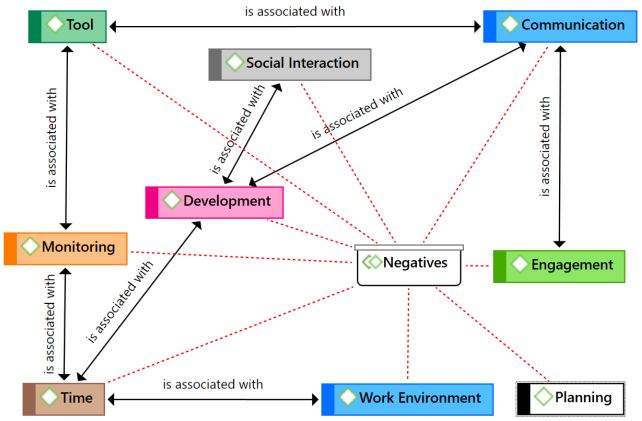


Figure 12: Categories and relationships identified for Q22

Monitoring the work in general was mentioned a lot in this research. A negative aspect was the duration of meetings, highlighted by **P1** with the following speech: "*many meetings on the same day or during the week ended up hindering performance*". This observation was recurrent both in the number of meetings that increased and in the duration. In relation to the tools, the way of following the projects often followed the format of online meetings, available on several platforms. However, with easy access to communication tools, which leads to a diversity and lack of standardization, in addition to the overload of meetings or virtual meetings. The comment by **P17** highlighted this aspect: "*Too many Meetings and the non-standardization of tools*".

The work environment can be a benefit if well structured, but there were mentions about being a negative point, especially as to how to use the time. The freedom of hours can sometimes be confused with being able to work at all hours, and this can harm both mentally and physically the developer. The comment by **P36** reinforced this negative point "*The lack of time limits to work. You don't have to commute from work to home. He's always at work and always at home*".

Communication was the category with the most relationships. Remote communication does not always perform well, even with a wide range of tools. This hinders development in several aspects, such as planning and monitoring. The mention of **P32** with "*With the distance from remote work, it was somewhat impaired since we have to wait for the teammate to be free on the communication channel to validate together*" highlighted the issue of overload and waiting times that remote work can cause, even with a variety of tools. Engagement was also not necessarily maintained or improved. Not all stakeholders have the same skills and availability to maintain remote communication, as highlighted by **P49** in "*Difficulty in remote communication, especially between different areas of the company*".

Even with remote contacts provided by tools in different formats, social interaction is necessary, pointed out by some respondents. This interaction can be for work as well as moments of relaxation or rest. This need was reinforced by **P43** with "*The human being is a social creature, we need to relate to others, it is a vital aspect of our own nature. The impossibility of having a greater coexistence in the office, for me, harms some essential aspects of a work that is done mainly in a team, such as team building*".

Perhaps due to the flexibility arising from remote work and ease of contact, many changes in scope and planning may arise more frequently than usual, impairing the project, as mentioned by **P61** with "*Not as much of the development itself, but the constant changes in scope and dates have hindered the team's planning a lot. Everything seems to be urgent nowadays*".

5 THREATS TO VALIDITY

The following analysis of the threats to validity to our study is based on the guidelines by Wohlin et al. [24].

Conclusion Validity. The collected data and the conclusions are valid for a period still pandemic, however where the developers have already obtained a good time of learning and experiences. The reports can be considered as lessons learned for companies, managers and developers. Some questions were open and subjective, so the participants answered according to their experiences. It is understood that there are also varying levels of knowledge in the tools used during the period of remote work. In addition, there is also the profile of the developers' companies who responded to the survey. All of these factors can influence the quality of the responses and, consequently, the conclusions.

Construct validity. The construct validity threat of the questionnaire is whether the survey can be understood by participants. To mitigate this, we conducted a pilot study with three participants who work in companies and also validate the questionnaire with two experts in software engineering (2 PhDs). The pilot helped us to refine the questionnaire for availability.

Internal validity. The threat to internal validity is related to the qualitative analysis process. We had two authors to code the answers separately. To reduce trends, each author performed the analysis multiple times, each time arriving at the same results.

Moreover, the authors compared their individual results and refined those until there were no disagreements.

External validity. A major threat is related to the sample size, which was 67 participants. Even getting answers from all regions of Brazil, the ideal was that the quantity would be much larger, and that the quantity of answers from a region would not be unbalanced. With more answers, the number of reports, tools, experiences and roles related to development would be much more complete, in addition to a greater number of participating companies.

6 FINAL REMARKS

Our study aims to analyze the impacts of WFH on Brazilian software development teams and changes in the software development process after 1 year of the COVID-19 pandemic. We applied a survey with 67 participants of software teams and investigated aspects, as: work routine, collaboration, communication, productivity, financial assistance and software development process. Our survey results were analyzed in a quantitative way using descriptive statistics and qualitatively using grounded theory.

Our key findings are: (i) 56.71% of the participants said that it has an impact on the work routine related to work overload and exceeds the company's standard hours; (ii) 92.54% of the participants consider their team to be collaborative; (iii) 82.70% are satisfied with the communication at WFH; (iv) 86.55% has meetings once or twice a day; (v) 59.7% had an improvement in productivity in WFH and 75% are satisfied with their productivity; (vi) 79.60% receive some assistance from the company for WFH; (vii) 82.1% said that the company intends or probably intends to continue in the WFH, and (viii) 55.2% said they had changed in the software development process due to WFH. The qualitative analysis revealed that meetings were the activities that most impacted the software development process, either positively for facilitating communication or negatively for overload. Also, version control and code review tools have been extensively explored, supporting development well.

As future work, the research can be extended to some actions, such as: (i) further investigate changes in the software development process at WFH and their impacts on other aspects such as productivity and customer expectations; and, (ii) analyze the impact of changes in the software development process at WFH on the software quality.

REFERENCES

[1] Carla I. M. Bezerra, José Cezar de Souza Filho, Emanuel F. Coutinho, Alice Gama, Ana Lívia Ferreira, Gabriel Leitão de Andrade, and Carlos Eduardo Feitosa. 2020. How Human and Organizational Factors Influence Software Teams Productivity in COVID-19 Pandemic: A Brazilian Survey. In *Proceedings of the 34th Brazilian Symposium on Software Engineering (SBES '20)*. Association for Computing Machinery, New York, NY, USA, 606–615. https://doi.org/10.1145/3422392.3422417

[2] Mridul Bhardwaj and Ajay Rana. 2016. Key Software Metrics and Its Impact on Each Other for Software Development Projects. *SIGSOFT Softw. Eng. Notes* 41, 1 (Feb. 2016), 1–4.

[3] Clara Caldeira, Letícia S. Machado, Marcelo G. Perin, and Cleidson R. B. de Souza. 2020. Remote workers' wellbeing in the age of COVID-19. (August 2020). https://www.microsoft.com/en-us/research/publication/remote-workers-wellbeing-in-the-age-of-covid-19/

[4] Edna D. Canedo and Giovanni A. Santos. 2019. Factors Affecting Software Development Productivity: An empirical study. In *Proceedings of the XXXIII Brazilian Symposium on Software Engineering*. ACM, 307–316.

[5] Juliet Corbin and Anselm Strauss. 2014. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

[6] Maitraye Das, John Tang, Kathryn E. Ringland, and Anne Marie Piper. 2021. Towards Accessible Remote Work: Understanding Work-from-Home Practices of Neurodivergent Professionals. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW1, Article 183 (April 2021), 30 pages. https://doi.org/10.1145/3449282

[7] Thaís Ferreira, Davi Viana, Juliana Fernandes, and Rodrigo Santos. 2018. Identifying Emerging Topics and Difficulties in Software Engineering Education in Brazil. In *Proceedings of the XXXII Brazilian Symposium on Software Engineering*. ACM, 230–239.

[8] Denae Ford, Reed Milewicz, and Alexander Serebrenik. 2019. How remote work can foster a more inclusive environment for transgender developers. In *2019 IEEE/ACM 2nd International Workshop on Gender Equality in Software Engineering (GE)*. IEEE, 9–12.

[9] Leigh Griffin. 2021. Implementing Lean Principles in Scrum to Adapt to Remote Work in a Covid-19 Impacted Software Team. In *International Conference on Lean and Agile Software Development*. Springer, 177–184. https://doi.org/10.1007/978-3-030-67084-9_11

[10] Claire M Hewson, Dianna Laurent, and Carl M Vogel. 1996. Proper methodologies for psychological and sociological studies conducted via the Internet. *Behavior Research Methods, Instruments, & Computers* 28, 2 (1996), 186–191.

[11] Brittany Johnson, Thomas Zimmermann, and Christian Bird. 2019. The Effect of Work Environments on Productivity and Satisfaction of Software Engineers. *IEEE Transactions on Software Engineering* (2019).

[12] Justin Lavelle. 2020. Shifting Some Employees to Remote Work Permanently | Gartner. Retrieved May 08, 2021 from https://www.gartner.com/en/newsroom/press-releases/2020-04-03-gartner-cfo-surey-reveals-\&74-percent-of-organizations-to-shift-some-employees-to-remote-work-\permanently2

[13] Krzysztof Marek, Ewelina Wińska, and Włodzimierz Dąbrowski. 2021. The State of Agile Software Development Teams During the Covid-19 Pandemic. In *International Conference on Lean and Agile Software Development*. Springer, 24–39. https://doi.org/10.1007/978-3-030-67084-9_2

[14] Courtney Miller, Paige Rodeghero, Margaret-Anne Storey, Denae Ford, and Thomas Zimmermann. 2021. "How Was Your Weekend?" Software Development Teams Working From Home During COVID-19. In *2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE)*. 624–636. https://doi.org/10.1109/ICSE43902.2021.00064

[15] Edson Oliveira, Gislaine Leal, Marco Túlio Valente, Marcelo Morandini, Rafael Prikladnicki, Leandro Pompermaier, Rafael Chanin, Clara Caldeira, Letícia Machado, and Cleidson de Souza. 2020. Surveying the Impacts of COVID-19 on the Perceived Productivity of Brazilian Software Developers. In *Proceedings of the 34th Brazilian Symposium on Software Engineering (SBES '20)*. Association for Computing Machinery, New York, NY, USA, 586–595. https://doi.org/10.1145/3422392.3422444

[16] Rafael Prikladnicki and Erran Carmel. 2013. Is time-zone proximity an advantage for software development? The case of the Brazilian IT industry. In *2013 35th International Conference on Software Engineering (ICSE)*. IEEE, 973–981.

[17] Paul Ralph, Sebastian Baltes, Gianisa Adisaputri, Richard Torkar, Vladimir Kovalenko, Marcos Kalinowski, Nicole Novielli, Shin Yoo, Xavier Devroey, Xin Tan, et al. 2020. Pandemic programming. *Empirical Software Engineering* 25, 6 (2020), 4927–4961.

[18] Paige Rodeghero, Thomas Zimmermann, Brian Houck, and Denae Ford. 2021. Please Turn Your Cameras On: Remote Onboarding of Software Developers during a Pandemic. In *2021 IEEE/ACM 43rd International Conference on Software Engineering: Software Engineering in Practice (ICSE-SEIP)*. 41–50. https://doi.org/10.1109/ICSE-SEIP52600.2021.00013

[19] Daniel Russo, Paul HP Hanel, Seraphina Altnickel, and Niels van Berkel. 2021. Predictors of well-being and productivity among software professionals during the COVID-19 pandemic–a longitudinal study. *Empirical Software Engineering* 26, 4 (2021), 1–63.

[20] Zacharias Schrage. 2021. *How Can Software Development Teams Be Controlled During the COVID-19 Pandemic*. Springer International Publishing, Cham, 87–103. https://doi.org/10.1007/978-3-030-66611-8_7

[21] Paulo Silveira, Umme Ayda Mannan, Eduardo Santana Almeida, Nachi Nagappan, David Lo, Pavneet Singh Kochhar, Cuiyun Gao, and Iftekhar Ahmed. 2021. A Deep Dive into the Impact of COVID-19 on Software Development. *IEEE Transactions on Software Engineering* (2021), 1–1. https://doi.org/10.1109/TSE.2021.3088759

[22] Ruoxi Sun, Wei Wang, Minhui Xue, Gareth Tyson, Seyit Camtepe, and Damith C. Ranasinghe. 2021. An Empirical Assessment of Global COVID-19 Contact Tracing Applications. In *2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE)*. 1085–1097. https://doi.org/10.1109/ICSE43902.2021.00101

[23] WHO. 2021. Brazil Coronavirus(COVID-19) statistics. Total and daily confirmed cases and deaths. Retrieved May 09, 2021 from https://covid19.who.int/region/amro/country/br

[24] Claes Wohlin, Per Runeson, Martin Höst, Magnus C. Ohlsson, Björn Regnell, and Anders Wesslén. 2012. *Experimentation in software engineering*. Springer Science & Business Media.

[25] Agustin Yagüe, Juan Garbajosa, Jessica Díaz, and Eloy González. 2016. An exploratory study in communication in Agile Global Software Development. *Computer Standards & Interfaces* 48 (2016), 184–197.