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CAN YOU HEAR ME?

A GROUNDED THEORY ON THE IMPACT OF THE COVID-19
PANDEMIC IN SOFTWARE DEVELOPMENT

MASTER IN COMPUTER SCIENCE

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ABSTRACT

Context: With the arrival of the COVID-19 pandemic, many software development companies had to urgently adopt remote work, even those who never resorted to it. This caused many challenges and uncertainties that software development companies never faced before. This led to a mixed bag of effects on the productivity of software developers, where there were positive and negative effects. Some of those effects would not be found when working at co-located offices.

Objectives: Our goal was to present and understand the different factors that come into play when working from home during a pandemic, what are their impacts and how companies have tried to deal with them.

Methods: In this dissertation, we use Straussian Grounded Theory, a qualitative methodology that makes use of semi-structured interviews and coding, to formulate a theory on the impact of the pandemic on software development.

Results: The resulting theory characterises in detail what were the challenges, such as social isolation, burnout, workspace, distractions, and benefits, like not having to commute, promotion of health, collaboration, communication, knowledge sharing, online events, which were found by software developers during the pandemic. It also characterises how the different aspects relate to each other, and how software developers had to adapt to the pandemic. We propose a set of recommendations, such as remote work flexibility, promotion of health care and social events, trust employees, based on the results we found, for companies that expect to adopt remote work in the post-pandemic.

Conclusions: The short-term impact of the COVID-19 pandemic has different impacts based on software developers context. Some of the impacts can change in the medium or long term. Overall, it is important to promote employees' health, well-being and communication to mitigate the negative impacts on their productivity.

Keywords: Software Development, COVID-19, Productivity, Grounded Theory, Working From Home, Remote Work, Challenges, Benefits, Post-pandemic

RESUMO

Contexto: Com a chegada da pandemia do COVID-19, muitas empresas de desenvolvimento de software tiveram de adoptar urgentemente o trabalho remoto, mesmo aquelas que nunca recorreram a ele. Isto causou muitos desafios e incertezas que as empresas de desenvolvimento de software nunca tinham enfrentado. Isto levou a um saco misto de efeitos sobre a produtividade dos programadores de software, onde houve efeitos positivos mas também efeitos negativos. Alguns destes efeitos não eram encontrados no trabalho presencial em escritórios co-localizados.

Objetivos: O nosso objectivo era apresentar e perceber os diversos factores que entram em jogo quando se trabalha a partir de casa durante uma pandemia, quais são os seus impactos e como é que as empresas tentaram lidar com eles.

Métodos: Nesta dissertação usámos a Straussian Grounded Theory, uma metodologia qualitativa que faz uso de entrevistas semi-estruturadas e codificação, para formular uma teoria que caracteriza o impacto da pandemia em desenvolvimento de software.

Resultados: A teoria resultante caracteriza em detalhe quais foram os desafios, tal como o isolamento social, o burnout, o espaço de trabalho e as distrações, e quais foram os benefícios, por exemplo a ausência de deslocações, a promoção da saúde, a colaboração, a comunicação, a partilha de conhecimento, os eventos sociais, que foram encontrados pelos programadores durante a pandemia. Também caracterizamos como é que os vários aspectos se relacionam, e o que é que os programadores tiveram de fazer para se adaptarem à pandemia. Também propomos um conjunto de recomendações com base nos resultados que encontramos, para as empresas que ponderem adotar teletrabalho na pós-pandemia.

Conclusões: O impacto a curto prazo da pandemia da COVID-19 tem impactos diferentes com base no contexto dos programadores durante a mesma. Alguns destes impactos podem vir a mudar no prazo médio a longo. De maneira geral, é importante promover a saúde, o bem estar e a comunicação para mitigar os impactos negativos na sua produtividade.

Palavras-chave: Desenvolvimento de Software, COVID-19, Produtividade, Grounded Theory, Teletrabalho, Trabalho Remoto, Desafios, Benefícios, Pós-pandemia

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ACRONYMS

CEO	Chief Executive Officer 12
COVID-19	Corona Virus Disease 2019 1
FP	Function Points 7
FTS	Follow-the-sun 6
GCS	Google Cloud Storage 19
GSD	Global Software Development 6
GT	Grounded Theory 8
LOC	Lines-of-code 7
ML	Standard Maximum Likelihood 76
MLM	Multi-Level Estimator 76
MLR	Robust Maximum Likelihood 76
OBS	Open Broadcaster Software 18
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2 1
SEM	Structural Equation Model 76
UK	United Kingdom 66
USA	United States of America 66
UX/UI	User usability and interface 12
WFH	Working From Home 19

INTRODUCTION

1.1 Context

Remote work can be described as the ability to do corporate work outside an office [41]. It has been adopted by software companies as an alternative to having employees physically present in offices. On March 2020, the world found itself faced with the [Corona Virus Disease 2019 \(COVID-19\)](#) pandemic, caused by the [Severe Acute Respiratory Syndrome Coronavirus 2 \(SARS-CoV-2\)](#) virus, which has an easy airborne transmission and can cause severe symptoms on those who are more vulnerable. Due to that, most countries entered a lockdown, where all non-essential commerce was temporarily closed, and those with the possibility to exercise remote work, such as software development companies, had to start working from home within a matter of days. This would end up re-occurring multiple times, since multiple lockdowns are necessary to contain the pandemic.

1.2 Underlying Problem

When governments forced companies to adopt working from home as full-time, a lot of software development companies did not have any experience with remote work or had very little, such as allowing employees working some days remotely [23]. Due to the sudden change from working in office to work from home, software companies had very little time to adapt to the new challenges that arose and to the enhancement of existing ones, causing many problems with negative consequences on their employees. These problems can include the lack of network infrastructures, lack of equipment outside of office, harder communication between employees, lack of work environment, among others. Some consequences of this were the decrease in the productivity of software developers [45].

But despite that, there were positive impacts that came with the work from home changes and made a difference, such as no longer losing time on commuting, increased comfort, and more time with family, among others [9, 19].

Some companies ended up being able to mitigate these problems but not all of them,

and these problems tend to amplify or attenuate based on multiple characteristics of the companies, projects and employees.

Many companies consider fully adopting remote work, or at least allowing hybrid remote work, to reduce the budget spent on office spaces, if the productivity is not heavily affected [2].

When taking all the changes, challenges and benefits that occurred during the pandemic into account, we formulated the research question we are investigating in this dissertation, which is the following:

How did the COVID-19 pandemic impact software development?

This main research question is composed by several sub-research questions, which are the following:

- How did the pandemic affect the software development process?
- What did companies do to mitigate potential challenges in development teams?
- How does the impact on other teams reflect on software development teams?
- What are the potential benefits of working remotely and hybridly?
- What changes do companies foresee after the end of the pandemic?
- What advices can be given to companies that want to support full or hybrid remote work after the pandemic?

1.3 Contributions

This dissertation contributes with a theory that addresses the challenges of software development companies and their employees when facing the COVID-19 pandemic, how they tried to mitigate those challenges, and how they affected the productivity and communication. We used the Straussian Grounded Theory to support our theory building process, and interview software developers, project managers, QA analysts and UX/UI designers.

Our ultimate objective was to uncover and understand what kind of changes companies expect in software development, and see how they improve the productivity of software developers during the pandemic, when compared to those implemented in more traditional in-office teams.

Our contributions also allows presenting the multiple benefits of working from home or hybridly, when compared to the more traditional co-located development offices.

Lastly, we provide a set of recommendations for companies on how to address working from home during a pandemic, to help them to adapt more easily, as well as recommendations for companies that intend to stay working from home post-pandemic, or adopt a hybrid model.

1.4 Document Structure

This document is divided into 8 different chapters besides this one, which are organised in the following way:

- Chapter 2 – [Background](#) focuses on various factors that allow to explain the context of the dissertation, such as the COVID-19 pandemic, remote work, software developer productivity among others.
- Chapter 3 – [Recruitment and Interviews](#) describes the process of finding participants for the research, the description of the population, the acquisition of data through semi-structured interviews, as well as the transcription of them.
- Chapter 4 – [Data Analysis](#), describes how, through the application of the different coding phases of Grounded Theory on our data from interviews, we were able to find categories, sub-categories and relationships. It also presents examples on the application of the different coding phases.
- Chapter 5 – [A theory on the impact of the COVID-19 pandemic in software development](#), presents the theory on the impact of the COVID-19 pandemic in the productivity, different categories, sub-categories and relationships between categories that compose it, as well as the different impacts on each.
- Chapter 6 – [Theory Discussion](#) reflects on the theory and the different impacts of its categories. It also presents some context based on pre-pandemic codes, as well as the expectations for the post-pandemic.
- Chapter 7 – [Related Works](#) discusses and compares the available research related to the productivity of software developers during the COVID-19 pandemic, and we compare our theory to them.
- Chapter 8 – [Conclusion](#) presents the conclusions of this dissertation, and the future work.

BACKGROUND

In this chapter, we contextualise some fundamental concepts and information for better comprehension of this research work. We address the following topics: **COVID-19 Pandemic, Remote Work, Global Software Development, Software Developer Productivity and Grounded Theory.**

2.1 COVID-19 Pandemic

On January 10th of 2020, the first reports of a novel coronavirus outbreak, which later became known as SARS-CoV-2, came from Wuhan, China [42]. This virus was first identified in December 2019 in the same city, in patients with similar symptoms to pneumonia. Later, the disease caused by SARS-CoV-2, would be called COVID-19 [59]. Due to the high and rapid transmissibility of the virus, it quickly spread globally and was declared a pandemic, the COVID-19 pandemic. The symptoms of this new pandemic disease were described as: (1) fever, (2) dry cough, (3) tiredness and, in most severe cases: (4) difficulty in breathing, (5) chest pain, and (6) loss of speech and/or movement [17].

While some people might test positive for the presence of SARS-CoV-2, not all of them are affected by COVID-19. However, those who are more vulnerable to it (elderly people, people with compromised immune system or respiratory tract diseases, cancer patients, among others) end up being severely affected by this disease, which might even lead to their death [64]. At the moment of writing, there are 5.15 millions of mortal victims, corresponding to 2% of the total infected.

The conjunction of these symptoms with the fast airborne spread in a globalised world led to a lot of countries' governments declare state of emergency, where under reason, is given the power to suspend some rights and liberties granted to citizens [54]. This led to several countries enter a lockdown, which caused most non-basic commerce to close and companies to leave their offices overnight, to prevent the spread of COVID-19. Since most software development companies reside in offices, with teams in person, this led to the need to urgently abandon office work and adopt working from home in a matter of days, which raised productivity issues. This happened several times to contain the rise of

number of COVID-19 cases.

2.2 Remote Work

Thanks to the evolution of the communication, remote-access and network technologies, being able to work anywhere despite the distance is becoming more and more common within companies [41]. The term Remote Work is defined as the working style of being able to realise organisational work outside an office, either temporarily or full time.

Since different companies have different needs, the remote work can be divided into several categories that have their own long-term benefits and disadvantages. GitLab, a company that is fully remote and distributed around the globe, published *The Remote Playbook* [24], which contains several guidelines and tips for other companies regarding remote work, and contains the following remote work style categories:

- **Remote-Allowed** – Companies allow employees to work some days outside the office, but it is still expected for them to spend time in the office. This allows for a compromise of flexibility between the employer and the employee.
- **Hybrid-Remote** – Certain teams or members of teams of the companies work fully remotely, while others from the very same companies require physical attendance. This allows for the employers that are committed to having physical headquarters to recruit exceptional employees that are in other locales as well.
- **Full-Remote** – All employees work remotely from where they want, giving them freedom, individual choices and valuing the results. In some cases, like GitLab, there might not be any company-owned offices.

While Remote Work allows for a huge flexibility while working, it also brings challenges and difficulties that usually are not faced when working in an office. Some studies and reports show that some of the advantages in working remotely are: (1) flexibility on where and when to work, (2) less commute stress, (3) ability to engage in globally distributed teams, and (4) money saving [26, 41, 46]. On the other hand, the disadvantages of remote work can impact negatively the productivity, with some of these disadvantages and challenges being: (1) lack of face-to-face communication makes it harder to build trust, (2) harder to separate work from other parts of life, leading to a decrease of balance, (3) managing distractions, (4) collaboration is more complex, (5) requires a good internet network and equipment, (6) managing projects becomes a more complex task, and (7) maintaining motivation is harder [18, 26, 46].

Recently, more technologies try to address these issues and improve the quality of life of employees. The most prevalent program and apps used for communications are *Microsoft Teams* [58], *Slack* and *Zoom* [7, 24, 31], which allow employees to communicate between them in real time and easily do meetings without much of a hassle. As for project

management, *Jira* [7] allows to track tasks. Software like *Git*, *GitLab* or *GitHub*, allows for a certain level of collaboration on software projects, as it allows to discuss and share around artefacts (commits, issues, among others) [11].

2.3 Global Software Development

In the last decades, globalisation has increased a lot and with it so has business globalisation, which eventually led to **Global Software Development (GSD)**, a software development paradigm where the teams of a company are located in different parts of the world. The Global Software Development came to answer some of the needs of companies, by giving them access to skilful resources with lower cost and more time efficient, resulting in lowering the overall software development cost [25]. Thanks to this, the paradigm in the last few years has been becoming one of the normal practices of the software industry.

While the geographic distance between the different teams is always present, it is not the only type of distance observed: Global Software Development is also composed by cultural distance (which includes linguistic distance, the different languages), and temporal distance (different time zones) [27, 65], which raises several challenges. For instance, the different time zones or native languages make team communication harder and the geographic distance leads to harder leadership and coordination [27, 37].

In some cases, these distances can bring some opportunities, namely, the temporal distance. Since the diverse teams are globally distributed, it means that most likely they work in different time zones. This allows to use strategies such as **Follow-the-sun (FTS)** [65], where the software development occurs on a time period of twenty-four hours, and the software is handed from one team to another after the work day is over, which decreases the time to market [14]. But, in reality, it might not be feasible because it demotes communication, and it is hard to implement [27].

Some of the practices used to address the identified challenges are, for example, to adjust the working hours to get a good overlap temporal between teams, to have as few dependencies among them as possible, to use *near shoring* (offshore destinations that are geographically close to the client), or to encourage travelling between offices, among others [27].

Regarding the tools used on Global software Development, they are very similar to the ones used in Remote Work, with *Microsoft Teams* [58], *Slack* [57] and *Zoom* [7, 24, 31], being some of the ones used for communication, *Jira* [30, 44] *GitLab* [24] and *Github* [30, 44] for collaboration and for project and task management.

An interesting topic of Global Software Development is how onboarding is done in globally distributed teams. Onboarding is characterised as the process of introducing and helping software developers adapting to their new teams, learning new knowledge and skills to become effective employees [8, 35]. While this process usually happens in person, in Global Software Development this is not always possible. There are a few formal models for onboarding, such as Jones' model [29] and Vaan Maanen and Shein's

model [33], but Bauer's model [4] is the one that is used more commonly in the process of onboarding. According to Bauer, a successful onboarding can be divided into six functions [8, 35]:

- **Recruiting** – Integration through realistic job interviews allows candidates to have a more candid idea about the company;
- **Orientation** – Helps to understand the important aspects of the job, its organisation and the company's values and culture;
- **Support Tools and Processes** - A written onboarding plan, stakeholder meetings and onboarding online can help a successful onboarding;
- **Coaching and Support** – Having mentors helps to acquire new knowledge more easily, provides advises and help with job.
- **Training** – Essential, to give clarity, confidence and skills in the new job.
- **Feedback** – It is important to receive it so that new developers are able to understand the reactions of co-workers.

In Moe, Stray, and Goplen's work [35], Bauer's model was applied to a globally distributed team, with the orientation aspect corresponding to a three-week stay with the team in Norway, and, the training aspect consisting of visits of mentors to Portugal. They concluded that Bauer's model is applicable to new developers who were recruited at the same time.

In Britto et al.'s work [8], Bauer's model was used as the base of a new process which allows companies to systematically create and evaluate an onboarding based on the individual characteristics of the various locations.

2.4 Software Developer Productivity

Improving the productivity of software developers is one of the main concerns of software companies and is currently a topic of higher importance in research. While software metrics like **Lines-of-code (LOC)** and **Function Points (FP)** can be used to measure the productivity of developers, they are not a good measure, since these only reflect on the programming aspect of their work and other than that they also have to attend meetings, realise code reviews, do presentations and more, which are not reflected on those metrics [13, 62].

There are studies that conclude that, despite the productivity depending on the development context and teams' characteristics, there are two types of factors that come into play when measuring the productivity, the *technical* factors and *soft* factors [62, 61, 13].

The *technical* factors are related to the development and practical aspect of the job and are usually represented by software metrics, characteristics of the solution and the

process of development itself, such as the product quality, software's size and complexity, the programming language being used, among others [13, 62].

All non-technical factors are *soft* factors, and they are related to human characteristics, companies and both team and work environment. These are for example: the developer's experience, skills and competences, proper workplace, team size and cohesion [13, 62].

On both cases, there are factors that influence negatively or positively the productivity, and it is possible to intervene in some of the negative ones to diminish their impact. As Wagner and Ruhe [62] stated, it is important for companies to list the productivity factors, to both analyse them and define what can be improved. But, it is important to balance between the different improvement actions, since neglecting some of the factors can cause dissatisfaction. This is particularly important since a developer's job satisfaction is strongly correlated to their perceived productivity, as shown by Storey et al. [56].

2.5 Grounded Theory

Grounded Theory (GT) is a qualitative research methodology, involving a systematic and inductive approach, where data is collected, analysed and used to generate a substantive theory, which describes processes. Unlike logico-deductive methods which seek data as evidence for a pre-existing theory, in Grounded Theory the theory emerges from the gathered data, generating concepts and categories from a pattern behaviour. This allows the researchers' idea regarding the theory to keep grounded in the data [1, 15].

The methodology itself can be divided into three different but rigorous phases [1]:

1. **The collection and analysis of data**, searching for patterns and concepts that will be aggregated into categories, also known as coding. There are two different types of coding: open coding, which generates concepts by asking generative questions; and selective coding, that tries to identify the core category that best explains the concern and is used later.
2. By comparing the different concepts and categories until we hit the theoretical saturation, we want to **develop the core category**, which addresses the main concern of the study and can be achieved with the selective coding. The **theoretical saturation** is when further data does not add new information to the existing categories. All components are well-supported, and it can be reached under three conditions: (1) no new data seems to emerge from a category, (2) the category is dense to the point all paradigm elements are covered, and (3) the relationship between the different categories is well established and validated [50].
3. Finally, **the theory is compared to the ones in literature**. This can happen at different times depending on what version of Grounded Theory one uses, since for some of them it is not desirable to start with a pre-conceived idea of theories.

During the Grounded Theory process, the researcher uses memos to capture and preserve concepts and ideas that emerge when analysing the data, since ideas and thoughts can easily be forgotten, and their usage can also help to raise the description to a theoretical level. [1].

The data for these processes can be collected from unstructured texts such as interviews and questionnaires to relevant stakeholders, documents, field notes or, in some cases, include structured texts, images, diagrams or even quantitative data [55].

There are three distinct versions of GT which share the same base processes: the Classic Grounded Theory (or Glaserian GT), the Straussian Grounded Theory and Constructivist Grounded Theory. Some key differences between these three are, for example: Straussian GT and Constructivist GT allow the definition of initial questions a priori, while the Classic GT defends that they should emerge from the research; they have different evaluation criteria; they have different paradigms, among others [1, 55]. Table 2.1 summarises the differences of different elements between the various Grounded Theories.

The version that will be used later on the research is the **Straussian Grounded Theory**, because it allows to have a research question beforehand, which will be used to structure the questions for data collection, and allows the usage of literature, which allows increasing the theoretical sensibility and will help to enhance concepts and questions.

Table 2.1: Comparison among the different Grounded Theory variants, adapted from [55].

Element	Classic GT	Straussian GT	Constructivist GT
Research Question (RQ)	Should not be defined a priori; Start with an area of interest.	Broad and Open-ended; May be defined in advance.	Set of initial Research Questions that evolve.
Role of the literature	Since the RQ is not defined, it's not possible to know which literature to check; Should be checked after the theory emerged.	Can be used during the process; Enhance Theoretical Sensitivity; Stimulate Questions	Delayed until defined GT; Opportunity to know what to do in the next sections.
Coding Procedures	Open Coding; Selective Coding; Theoretical Coding.	Open Coding; Axial Coding; Selective Coding.	Initial Coding Focused Coding Theoretical Coding
Questions asked during analysis	"What is the data a study of?"; What category or property does it fall into? What is happening in the data?	Whom, when, where, how, with what consequences, under what phenomena?	"What is the data a study of?" What does the data suggest? From whose point of view?
Evaluation Criteria	Generated Categories must fit the data, the theory should be able to explain or predict and must be relevant to the area; Must be modifiable if new data appears	Seven criteria for the research process; Eight criteria about the empirical grounding	Credibility; Originality; Resonance; Usefulness

For the Straussian Grounded Theory, according to Corbin and Strauss [16], the seven criteria for the research allow a reader to more easily judge the adequacy of the research process.

The seven criteria are: (1) How was the original population for the research selected? (2) What major categories were found? (3) What were the events, incidents or actions that indicated these major categories? (4) What happened after finding the categories? How was the collection of more data done? How did the literature help guiding the data collection? (5) What were some of the hypotheses regarding the relationships between categories? How were they formulated and tested? (6) Did some of the hypotheses not hold up against what was expected? How were the inconsistencies considered? (7) How was the core category selected?

These criteria can be used as guidelines to evaluate the research process of this dissertation.

It is specially important to fully understand the several aspects of the Straussian Grounded Theory, since in the following chapters we will use it to analyse our data and build our theory.

RECRUITMENT AND INTERVIEWS

To start working towards our theory, first we needed to recruit individuals who are interested to participate in the research, and that fit into the expected profiles. After recruitment, we started conducting our online interviews based on a script previously defined, to obtain the necessary data to proceed with the Grounded Theory steps. Both these processes allowed us to have some initial ideas of what our data is about, albeit without much detail.

3.1 Recruitment Methods

For the recruitment of participants for the interviews, we employed two different strategies: Convenient Sampling and Snowball Sampling.

Convenient Sampling – We leveraged our personal contacts to identify a pool of software development professionals who would be interested in participating in the research. We sent individual invitations to them, which briefly explained the context of the research and provided some info about the interviews. Upon invitation acceptance, we scheduled the interviews. This was our primary method of recruiting participants for the interviews.

Snowball Sampling – Our secondary method for recruiting participants for interviews consisted in asking the interviewees if they could identify other potential interviewees who might be willing to participate in the research. After that, we would either send an invitation for the interviewee to send to who might be interested, or the contacts were given by an interviewee, and the invites sent. While we contacted some potential interviewees through snowball sampling, no interviews resulted from it.

During the recruitment phase, we had a special care including some diversity, by limiting the amount of people of each role to one for each company. In other words, we would interview, at maximum, one person of each role in a company. The reasoning behind this was because teams tend to have similar experiences during software development, since they have the same work context, and it could possibly introduce bias toward what happened in those certain teams and/or companies.

Regarding the platform used for conducting the interviews, Zoom would be the preferred one by default, since it allowed to easily record meetings, and it separates the audio from the video, but before the interview, interviewees would be asked if they had any preferred platform. Due to different reasons, such as concerns about security, easy of use, or availability, other platforms, such as Microsoft Teams, Discord, WhatsApp and Google Hangouts were used to realise the interviews.

In total, we invited 29 people, and conducted 20 interviews, leading us to a 68,9% response rate. From the nine people who did not participate in the interviews, eight did not reply to our invitation, and one said that due to their home environment, they could not participate.

3.2 Consent Form

Due to the need to record interviews, we created a form related to GDPR agreement that interviewees had to quickly answer before the start of the interview. The first section of this form contained a quick description of the research, the estimated time for it, the contacts of both advisers and the student. Regarding the GDPR, in the initial section we remind the interviewee that the participation is voluntary, and as such, the interviewee is free to give up or refuse to answer, and that the interview would be recorded, transcribed and analysed, and its data anonymized. To progress, interviewees must agree with the terms, which would lead to the second section.

The second section is mainly to gather some demographic information such as age, role, experience and type of company, not only to give some background information for the interview, but also for statistics to describe our population.

To guarantee the anonymization of the participants, the participants are assigned an identification number, which is related to their interview and used through all of the following steps.

3.3 Population

For our research, we focused mainly on recruiting individuals who worked, or were currently working during the pandemic in the area of software development. Out of those, we chose five particular profiles to interview: Software Developer, Quality Assurance Analysts, [User usability and interface \(UX/UI\) Designer](#), Manager and [Chief Executive Officer \(CEO\)](#).

- **Software Developer** – The main subjects of the research. They are the responsible ones for creating, testing and developing software according to existing problems (needs of users and others) as a solution for them.

- **Quality Assurance Analysts** – They may be members of a different team that strongly interacts with the development team, since they are responsible to guarantee the good quality assurance and correct behaviour of the software. As such, they also offer an interesting perspective on another side of software development, as well how the quality of projects was affected, which in turns allows us to understand some of the impacts of the changing working conditions on software development.
- **UX/UI Designer** – This role is responsible for designing the user experience and interface that end-users will interact with. They usually do not belong to development teams, but work very closely with them, and as such it would be interesting to see how teams adjacent to developers are affected by the COVID-19 pandemic and how that translates into impacts on development teams.
- **Managers** – They are responsible for the planning, allocating resources, executing, monitoring, controlling and closing of projects. They tend to help and lead developments teams, and as such they are able to give important perspectives on the COVID-19 pandemic. They can be Team Managers, Project Managers, Engineering Managers and others.
- **CEO** – They are the highest-ranking executive in a company, and as such have the responsibility to make major decisions. They allow us to have a glimpse at how decisions regarding the pandemic were taken, and on the future of software development.

From our statistics, we found that the average age of an interviewee is 30,9 years-old, the median is 30,5 years-old, the standard deviation is 10,7 years, and the maximum age interviewed is 60, while the minimum is 22. To illustrate the distribution of ages, we represent a kernel density plot on [Figure 3.1 – Kernel Density Plot for the Age Distribution](#), where we can see that the highest age density happens in the range between 20 and 40 years-old.

For the gender of the interviewees, 15 people identified as Male (75%), while the other 5 identified as Female (25%). We did not interview anyone who identified as non-binary.

About the roles of the interviewees, 8 people were Full-stack Developers (40%), of which one also does quality and assurance tasks, one person was a Front-end Developer (5%) and another a Back-end Developer (5%). Two people were Data Scientists (10%), and another an Automation Engineer (5%). In total, developers are 65% of those who were interviewed. The manager positions make about 20% of the interviewees, with one person being a Team Leader (5%), one being the responsible for testing (5%), and two engineering managers (10%). We also interviewed a UX/UI Designer, who makes for 5% of the participants. Finally, we were able to interview two people with CEO positions (10%). The [Figure 3.2 – Total of Interviews per Role](#) summarises this total of interviews done per role.

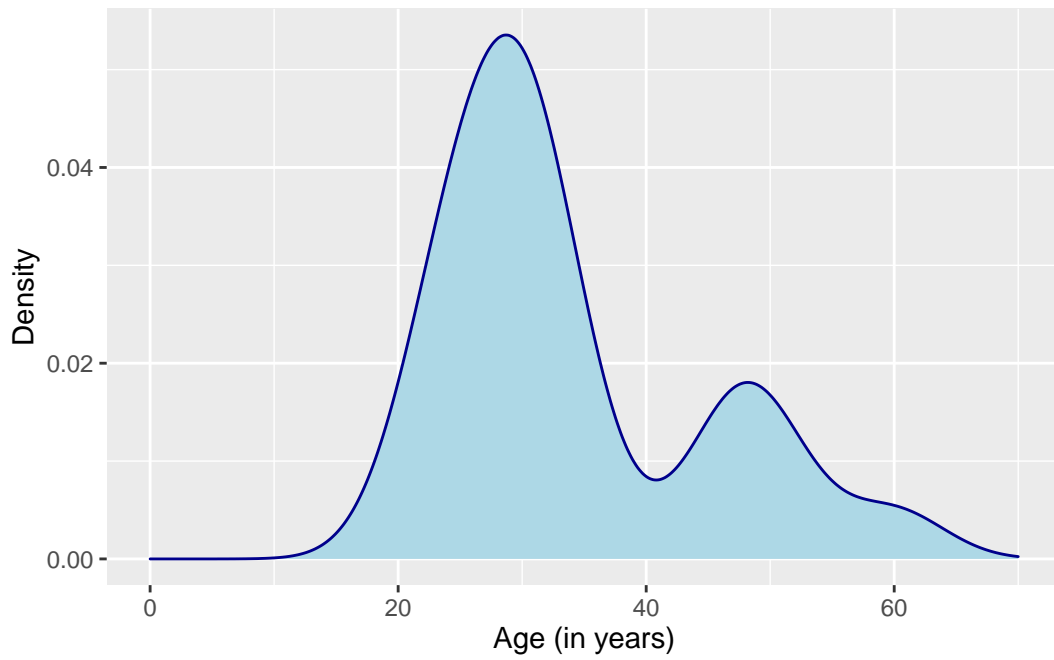


Figure 3.1: Kernel Density Plot for the Age Distribution

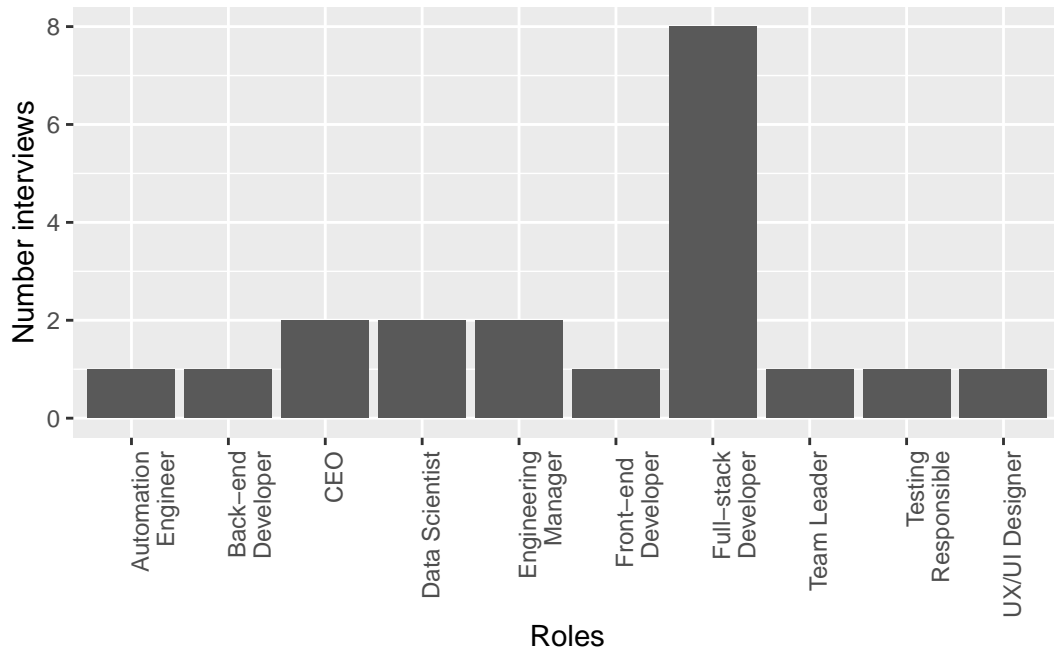


Figure 3.2: Total of Interviews per Role

Regarding the business and engineering areas we interviewed, we had two interviewees working in the Banking area (10%), two working in the E-commerce area (10%), one on scientific research (5%), one on the education area (5%), three on the call-center product area (15%), four from the telecommunication area (20%), one from the electricity area (5%), two from the multimedia area (10%), one works on migration of platforms (5%), one related to open-source (5%), two to a code acceleration area (10%). The [Figure 3.3 – Total interviews per Development Area](#) summarises the number of interviewees per development area.

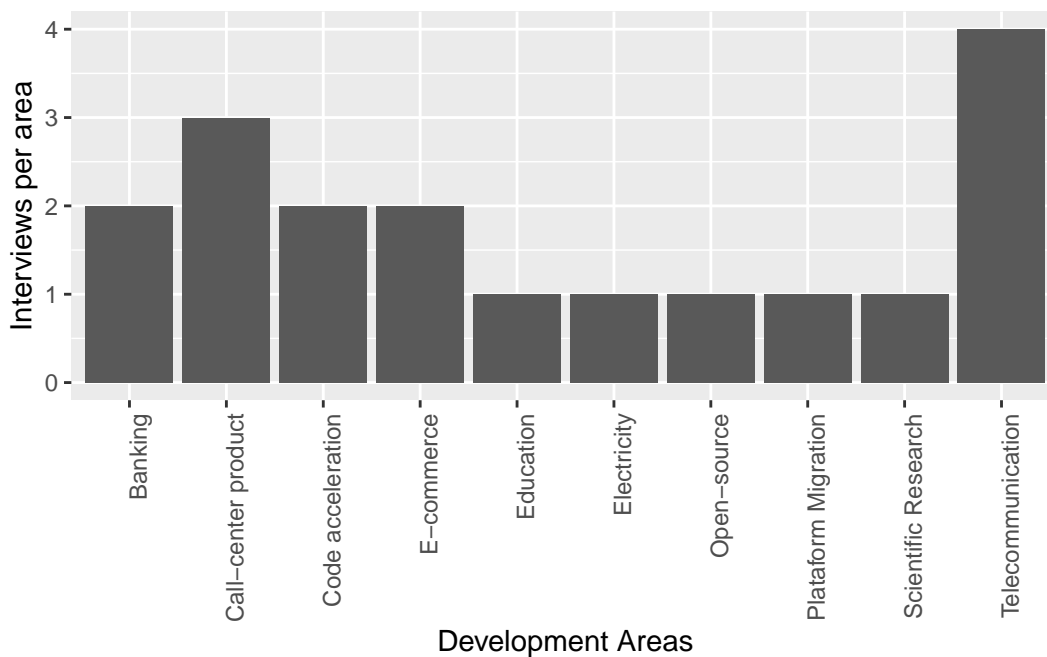


Figure 3.3: Total interviews per Development Area

Concerning the experience our interviewees had in the software development area, we found an average of 9 years, median of 6 and half years, a standard deviation of 9 years and half, a maximum working time of 34 years and a minimum of 3 months. About the time of an interviewee working on the current role, we found an average of 5 years (rounded), a median of 3 years, a standard deviation of 6 years (rounded), a maximum of 23 years in the same role, and a minimum of 3 months. On the [Figure 3.4 – Distributions of Years in Role and Years in Area](#) can be found a Kernel Density Plot for both of the previous statistics, where we can see that for the time in a role, most of the density falls between 0 and 12 years, while for the time in a development area extends to 16 years.

As for the size of the companies our interviewees work on, excluding CEOs, we have that 3 people (16%) are uncertain of the company's size, 4 people (22%) work in a company with 10 to 100 employees, 2 (11%) in companies with size between 100 and 500, one person (6%) works in a company with 500 to 1000 employees, 7 (39%) work in a company between 1000 and 5000, and finally one person (6%) works in a company with over 5000

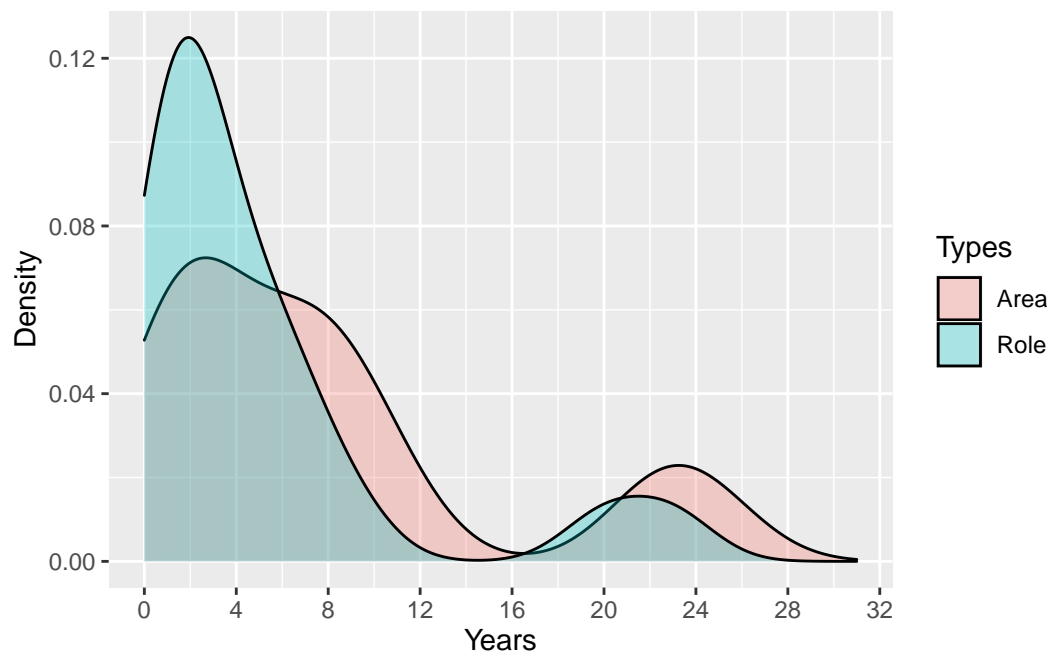


Figure 3.4: Distributions of Years in Role and Years in Area

employees.

Other statistics that we were able to get from our interviews were: (1) that out of all twenty interviewees, none lived with someone who had a disability, (2) only 4 people (22%) lived alone (excluding CEOs), while the rest lives with adults, (3) only four people have children.

3.4 Interview Conduction

We took a semi-structured approach to our online interviews, mainly through the platform Zoom, which means that we had a defined set of questions to ask the interviewee, but at any given moment, new questions could be asked based on the given answers, and there were no default answers, so interviewees could give any possible answer. The interviews were conducted by the M.Sc. candidate.

On a prior phase, we defined a draft of the base questions that would be done in the interviews, and we divided it into four different sections:

- The first section starts with demographic questions, and delves into the person's experience with remote work during the pandemic, dedicated office space, distractions, equipment, communication, collaboration and the impact of COVID-19 – which allows us to have some insight on the direct struggles that were found during the pandemic, but also to understand which other personal areas impacted one's productivity;

- The second section is about the experience of the interviewee in their role during the pandemic, and how it changed. In the case of developers, we asked about changes in the process, if they found any changes in their working schedules, if they felt impact from other teams, among others. As for QA analysts, we asked if the pandemic reflected in changes on the quality of the software and if the testing process was harder or easier. For the UX/UI designers, we focused on how the design process changed and if this somehow reflected in them having to learn programming or new technologies. As for managers, our questions focused on how their role changed during the pandemic, if the pandemic affected their trust on teams, how they dealt with team challenges, among others.
- The third section is about the interviewee's well-being and health during the pandemic, with a special focus on the physical and mental health. Our questions focused on how and what companies tried to do to help their employees deal with all the effects from the pandemic;
- Our final section is about the interviewee's perspective on the post-pandemic reality and what they would expect from it – Focusing on what they expect of remote work post-pandemic, if they expect any changes in their career progression, if it would be interesting to keep online social events, how regulations should change and more.

Out of the five roles, only one of them required a different interview structure: the CEO. Since they usually do not develop software, but are responsible for major decisions, we are mainly focused on the process of decisions related to the pandemic, and which decisions they are planning for the future. As such, the CEO interview structure is reduced, being composed by two sections: the first one focuses on decisions taken leading to the pandemic and during it, and the latter section focuses on the company's expectations for remote work.

The final version of the base interview questions can be found in the [Appendix A – Base Interview Questions](#).

We conducted a pilot interview to assess the draft we had in terms of duration, questions and structure. Overall, the structure did not have any changes, and regarding the questions, we had some changes on the wording for more clarity, since there were some doubts about what we were asking, and we also introduced more some questions. As for the duration, the pilot interview took 40 minute, which was close to our initial estimate of 45 minutes.

After conducting our pilot interview and finishing the details of our draft, we created a script for the interviews to give some insights to the interviewee about the research, the structure of the interview, reinforce that they can give up at any moment, and that data would be anonymized.

Then, we started conducting the interviews by following the set of questions that we had. While hearing more about their answers, we would try to capture some relevant

topics that might be worth deepening, and ask them questions about it. This would lead to new information that otherwise maybe could not be obtained. Some examples of these topics would for example be onboarding (for interviewees who started new jobs during the pandemic), meeting teammates during the pandemic, and working in the office during the pandemic, among others.

When asking questions, we usually would not give help or ideas, and would let the interviewees allow to gather their thoughts and say something based on their own experience with software development during the pandemic. In a few cases, where the interviewee would not understand the context of the question, or had difficulty answering it, we would give some context and examples of what we were asking about, which would allow the interviewee to unlock some thoughts and ideas about the subject.

During the interviews, we would also pay attention to duplicated topics in different interviews – for example similar opinions and experiences, which would help us at a later stage in recognising certain patterns.

At the end of each interview, we would ask the interviewee if they had anything else they would like to say – and there were two interviewees who added something else. This suggests that in general, our questions were able to cover the most important subjects of the remote work experience during the pandemic.

In total, we did 20 interviews and, based on our statistics, the average duration time of an interview was 35 minutes and 9 seconds, the median was 30 minutes and 20 seconds and 17 minutes and 46 seconds for standard deviation. The maximum duration was 1 hour, 32 minutes and 37 seconds, while the smallest interview had a duration of 16 minutes and 37 seconds. The [Figure 3.5 – Kernel Density Plot for the Interview Duration](#) presents the density of the duration of interviews in minutes, where we can see that most interviews have a duration between 15 minutes and 45 minutes.

3.5 Interview Transcriptions

After conducting the interviews, we started their transcription. The software used for the recording of interviews were Zoom's record functionality, which records both video and audio separately, or [Open Broadcaster Software \(OBS\)](#), when recording capabilities were not available, which was the case for communication tools that do not have recording capabilities integrated in them, such as Discord and WhatsApp. We searched for software programs to aid us at speeding up the process and providing a more accurate transcription, with the requirements that it had to support file input, multiple file formats, and Portuguese language. Unfortunately, the options that fulfilled these requirements were paid, and as such, other alternatives had to be found.

Both Microsoft Office Word and Google Docs have dictating functionalities, but do not accept file inputs, and when allowing the computer to hear its own sound through an Audio Virtual Cable, it takes as long as the duration of the interview, and it is not possible to hear the sound coming from the computer. When using an external sound source (for

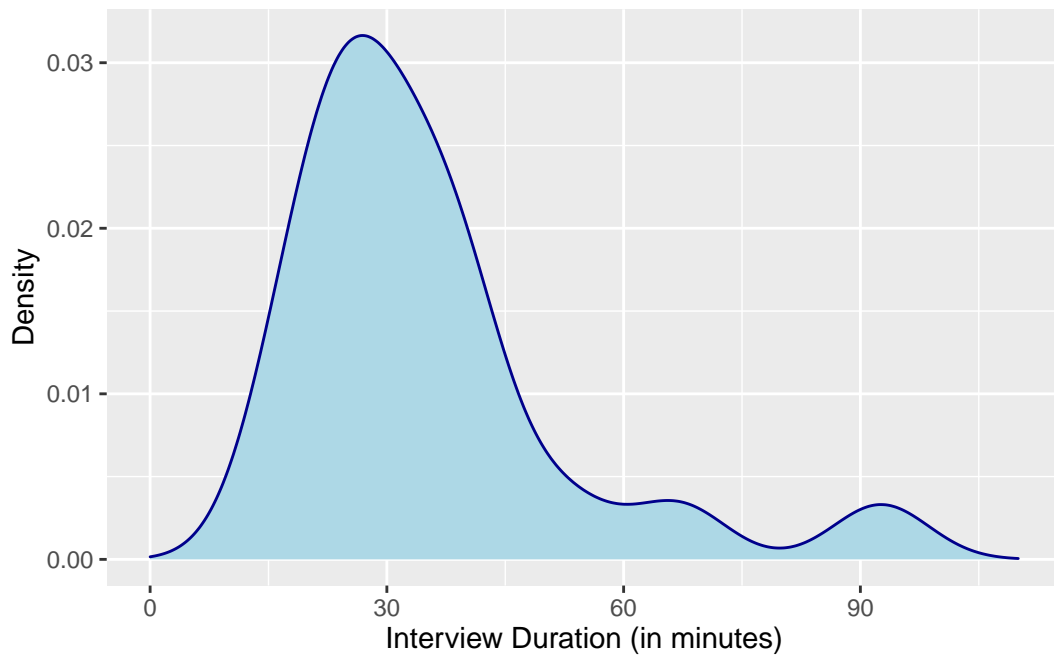


Figure 3.5: Kernel Density Plot for the Interview Duration

example, a smartphone), the quality of the transcription was very low, since it did not recognise many words, and those that it did, were wrong.

Eventually, we found that Google Cloud had a Speech to Text API [53] which fulfilled all the requirements we had previously defined. As such, we created a project on Google Cloud and programmed a short Node.js script to interact with the API, which grabs the file from [Google Cloud Storage \(GCS\)](#), sends the URI to the API, which in turn transcribes and sends the transcription back, and then it is written locally in a text file.

The API has some extra configurations that help at the transcription, such as the speaker diarization, which is the process of identifying and partitioning different speakers in a recording, and automatic punctuation. Unfortunately, neither of them is available at the moment for European Portuguese.

In our first transcriptions, we extracted the audio from a MKV file (OBS' recording extension) to MP3 with the `ffmpeg` tool, and while the API was able to do the transcription successfully and quickly, it had many spelling errors and missing words. When converting Zoom's audio recording (M4A) to MP3, we observed the same thing happening, and the same happened with people who had an almost perfect dictation. We started trying other configurations, such as changing the sample frequency and formats, specifically Lossless formats such as FLAC, but we had some issues utilising it with the API. Eventually, we tried the WAV format, which showed positive results, as the transcriptions eventually increased their accuracy, but kept failing some keywords, such as "Pandemic" and "[Working From Home \(WFH\)](#)". To improve in that aspect, we ended up providing some speech context words to the API, which helped to improve the transcription even

further.

After each transcription done by the Google API, we would manually review the transcription, by hearing the recording and reading the transcription simultaneously, to make the necessary changes, such as changing wrongly transcribed words, and guarantee that no information from the original interview was lost in the process of transcription.

The [Figure 3.6 – Interview and Transcription Process](#) illustrates the whole workflow of the interviews end-to-end, starting from the audio capture and ending on the reviewed transcription.

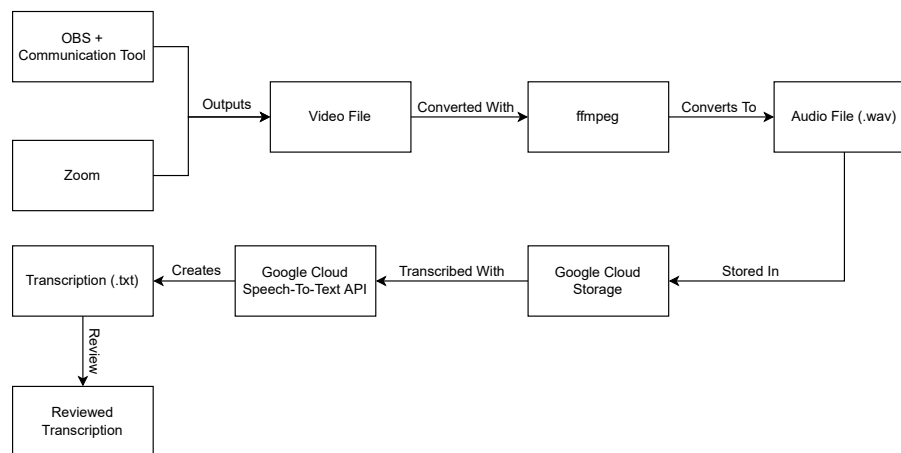


Figure 3.6: Interview and Transcription Process

We observed an increase of transcription accuracy in our final interviews, but we are unaware if it is due to the change of the audio format, or if Google API’s neural network was progressively learning more about the pandemic context, but as we progressed we definitely saw an improvement on the transcriptions.

When reviewing the transcriptions, we would also try to guarantee anonymization, where any direct reference to the company and the participant, such as names, locations or specific descriptions were removed, as well as any indicator that might lead to a specific characterisation.

An example of how review of a transcription occurred is the following, which was done during the interview E16:

“How was the Development process done pre-pandemic?”

When using the Google Text to Speech API to transcribe the answer to this question, which was in Portuguese language, we obtained a transcription, and the following excerpt is a transcribed part of it:

“ e para todos os quadros para saber tanto soluções evolutivos muitas coisas enquanto equipa agora é mais individual portanto agora é vamos lá naquela coloca liguei não tar a falar com outra pessoa é menos é mais individual agora e não é tanto em equipa começa aspectos tem alguma coisa e os vídeos do jogo eram super naturais agora eu quero problemas com um bocadinho conduzir e depois sempre fui muito com a minha com pessoas macaquinhos com outras pessoas e agora estamos um bocadinho mais nisso em casa e porque é mais difícil mas as pessoas têm filhos tem horários diferentes portanto não nunca é uma coisa tão cinco na Como arranjar um processo mais 18 hora aí ”

In this excerpt, there was an initial part of the answer missing, as well as punctuation. But, while some words were transcribed rightly, a lot of them do not make sense, and it is hard to understand where phrases start and end, and alter the whole meaning of the answer.

After reviewing the transcription while listening to the audio, the result is much more intelligible and clear:

“É assim, nós normalmente juntávamo-nos muito para discutir ideias, e juntávamos-nos muito à volta de quadros para fazer desenho de soluções enquanto equipa, agora é mais individual, portanto agora é vamos falar naquela call com alguém, juntar a outra, ou continuar a falar com outra pessoa, ou seja é mais individual agora, e não é tanto em equipa, nesse aspeto faz alguma diferença, depois na implementação também estávamos super habituado a fazer pair programming, e os pedidos de ajudam eram super naturais, agora o pair programming foi um bocadinho reduzido, e depois sempre funcionámos muito com alinhar com pessoas, marcar reuniões com outras pessoas, e agora cortamos um bocadinho mais nisso porque estamos em casa, e porque é mais difícil, e há pessoas têm filhos, tem horários diferentes, portanto nunca é uma coisa tão síncrona como era antes, é um processo mais solitário.”

Which, translated to English, is the following text:

“So, normally we would get together a lot to discuss ideas, and we would join around whiteboards to draw solutions as a team, while now it is more individual, so now it is more like talk with someone on a call, join another, it is not so much as a team, in that aspect it makes some difference, later in the implementation we were also used to do pair programming, and help requests were super natural, now the pair programming was a bit reduced, and we always worked a lot with align with people, schedule meetings with other people, and now we cut that a bit because we are at home, and it is harder, there are some people who have children, who have a different schedule, so the development is not as synchronous as it was, it is a lonelier process. ”

This process was crucial to ensure that the transcribed data matched the one from the audio interviews, and that no information was lost.

3.6 Theoretical Saturation

During our research, we took a special care with monitoring the theoretical saturation, where during our interviews we would carefully listen and pay attention to them to see if any new information was mentioned. To ensure that we approached theoretical saturation, at a later phase, we kept track of the number of new codes per interviewee. For our final consideration of the theoretical saturation, we mainly paid attention to the new codes of developer interviews, since they were the majority, and the initial section of the interviews were shared amongst most roles. The [Figure 3.7 – New codes per Developer Interview](#) shows how initially we had a lot of new codes, and how at the end the number of new codes tended towards zero.

The conduction of online semi-structured interviews was specially important, as it allowed to deepen some topics during them, and the transcriptions allowed to have a first contact with the data. All of the following chapters' information are based on the data acquired from the interviews.

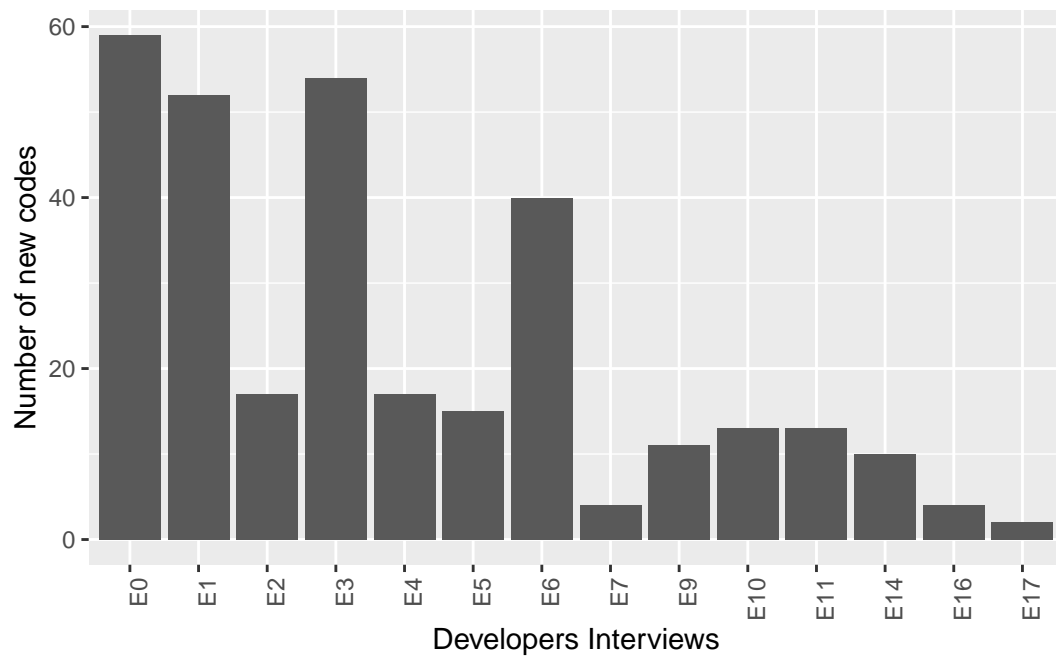


Figure 3.7: New codes per Developer Interview

DATA ANALYSIS

According to the Straussian Grounded Theory, the coding phase of Grounded Theory is the process where we start cleaning our data, finding and extracting the relevant data, structuring it, and finding relations. This process can be defined in three different phases: the Open Coding, where we start extracting our relevant data from interviews, and labelling codes and categories; the Axial Coding, where we look at our codes and find relationships between them, allowing us to relate and structure data; and finally the Selective Coding, where we review our structured data and try to find one or more core categories.

After this process is over, we find all the codes and the categories that contain them, and visually represent them.

4.1 Open Coding

The first phase of the quantitative analysis is Open Coding, and is when the interviews' transcriptions are first analysed, turning them into small and discrete data components, called categories and codes. The goal of open coding is to find the multiple properties of the data, label them and ensure that different pieces of data about the same subject are labelled together.

The first step to our open coding analysis was to carefully read our interview transcripts, and when finding a relevant word, phrase or passage about a theme, we would write a Memo about it. We used a Google Documents file to keep track of codes, as well as the citations associated with them, and the identifier of the interview. As we read more interviews, we would keep comparing the Memos looking for new codes, and in case we found repeated codes, we added them to the occurrences of the respective codes to keep track.

At the start, this process could take several days or a whole week for a one-hour interview, but as we progressed, it was more likely that we would find already existing codes in the following interviews – which would quickly speed up the process. By the end of the reading, a single hour interview would take only a single day, instead of a whole

week to process.

During this process, we started to see certain patterns and similar topics between the codes that we found, and we started to group them into categories, to make their analysis easier in a later phase. Some of the categories that we created were, for example, communication, which covered everything related to the communication during the pandemic, and also work equipment, which covered the usage of equipment during the pandemic. While most codes ended up having a category, some of them did not fit in a category and were left alone, usually due to the specificity of the topic that the code covered. These codes would end up not being part of the final theory.

Since the data from our research is time sensitive, and in our categories we could find codes referring to different timelines, we found it important to separate the codes inside each category into one of three different timelines: the pre-pandemic, the pandemic, and the post-pandemic. We analysed our codes to understand where they fit in the timeline – if they refer to something that happened pre-pandemic, it would fit into that category. For the codes that are explicitly about the experience during the pandemic, changes, among others, we would put them into the correct timeline. As for everything related to the future, such as expectations for the post-pandemic and more, we put them in the respective timeline.

While most categories have all three timelines, that is not the general rule. In cases there are no codes for a certain timeline, we omitted them, to make it clear we found nothing relevant to that category in that timeline. In a few special cases, where the category is explicit about the timeline (for example, post-pandemic remote work expectations), we did not put other timelines in it, since they would have been superfluous.

As our categories grew, we eventually observed that some of them were becoming too general: while a category did indeed cover a certain topic, inside it there were multiple different aspects to it, and even some of those would contradict each other. As such, we decided to create a taxonomy based on the categories, where each category would have multiple sub-categories to categorise the different codes it contained. To create them, we looked at each category and at the codes contained in it, and looked for similar patterns or topics inside the same timeline. We would then group them into sub-categories, with names that try to generalise those codes. An example of this would be, in the categories we previously mentioned, communication would end up with several sub-categories such as the benefits in the communication during the pandemic, the struggles and more and, as for the equipment, the acquisition of them and more. While we found sub-categories for most codes, not all of them have one, as there is not a way to generalise them, or do not fit in any particular sub-category.

In the end, we obtained a table for each of our categories, which is divided into different timelines, and inside those timelines, there are multiple sub-categories, each with multiple codes inside it.

We will show some examples on how the open coding was exercised, by demonstrating this process with raw data from some interviews.

On our interviews, we asked the following question:

“Do you feel that it is easier to hit burnout while working from home?”

and on our interview with the identification E06, we had the following response:

“I think so [that it is easier to reach the burnout] because to avoid burnout it is necessary to let’s say change scenery, and the easiest way is literally to change the space, and without being possible to leave home, that ends up being much more complicated, and I felt that in fact, without a doubt, it is much easier for a person to get super tired to the point where no longer can see anything in front of them, because they cannot... literally has the necessity to leave home and cannot, literally leave but also leave that state of mind, let’s say. ” [6].

From this piece of raw data we can observe some themes: being easier to burnout during the pandemic, as told by E6 *“I think so [that it is easier to reach the burnout] because to avoid burnout”*, it is more complicated to leave home during the pandemic *“and without being possible to leave home”*, not being able to leave home negatively affects cognitive functions *“it is much easier for a person to get super tired to the point where no longer can see anything in front of them”*, and difficulty in leaving a certain state of mind *“literally has the necessity to leave home and cannot, literally leave but also leave that state of mind, let’s say”*. Upon looking at more detail, we can see that all the themes have something in common: not being able to leave home due to the pandemic causes all those negative effects that were reported in this interview, but we asked ourselves why this happens, and we found that it is due to having difficulties at separating mental spaces (between work and leisure) that this occurs. As such, we created a code "Hard separation of work from leisure makes it easier to hit burnout", with the quote *“I think so [that it is easier to reach the burnout] because to avoid burnout it is necessary to let’s say change scenery, and the easiest way is literally to change the space, and without being possible to leave home, that ends up being much more complicated (...) [E6]”* associated to the code.

As for a more extensive example, lets take into account the interview E10. In that interview, we did the following question:

“Did online social events help you adapt to the pandemic?”

from which we received the following answer:

“Yes, due to the lack of physical contact among all colleagues, for example sometimes we would each one take some snacks, each person took whatever they wanted to eat, a beer or a cider or whatever, and we would be there chatting like we were at a coffee shop, but each one at their own house, that helped yes because, at least for me, and I know a lot of people felt that way, they missed interactions with colleagues, whether it was playing table football at lunchtime, whether it was a coffee during the day and stuff like that, there were some people, and I at least talk about myself, that missed the interaction with people physically, and it helped.” [10].”

There is a lot of information in this answer, so let's dissect it bit by bit: the interviewee confirms that indeed social events helped to adapt *“Yes, due to the lack of physical contact among all colleagues”*, that they would interact virtually as if they were on a coffee shop together *“ for example sometimes we would each one take some snacks, each person took whatever they wanted to eat, a beer or a cider or whatever, and we would be there chatting like we were at a coffee shop, but each one at their own house”*, and that the lack of interaction was something missed *“and I know a lot of people felt that way, they missed interactions with colleagues”*. When looking for the answer to our question, we were able to find it in the last part of the text, *“and I at least talk about myself, that I missed the interaction with people physically, and it helped”*, which refers to online interactions compensating the lack of physical interactions, and as such, we created a code "Social events helped adapting". To complement this code, and give some context, we decided to ask our data what kind of interactions substituted the physical ones, from which we found that virtual coffees was one of that kind *“ for example sometimes we would each one take some snacks, each person took whatever they wanted to eat, a beer or a cider or whatever, and we would be there chatting like we were at a coffee shop, but each one at their own house”*, and as such we created a new code "Virtual coffee as social event".

Next, we will show an example of how the sub-categories were formed: In the context of the pandemic, we found several reports about developers who worked in office during the pandemic, and we asked if there was any type of measures for COVID-19 prevention. From those questions, three codes emerged: *“Temperature recording system for office access”*, which mentions the usage of a temperature tracking system to work in office, *“COVID-19 prevention measures offered more security in office”*, meaning that a person felt more comfortable to work in person with the measures in place, and *“Usage of COVID-19 prevention measure in office”*. Since all three refer to measures taken for or during office access, we created a sub-category "COVID-19 prevention for office access".

Finally, we have an example for how a category is formed. From grouping our codes into sub-categories, we found sub-categories about *“Promotion of physical health”*, *“Challenges of physical health”* and *“Lack of physical health promotion”*. Since all three sub-categories refer to physical health, we created and grouped them into a category called

"Physical Health".

This process was our first and most important interaction with our data, as it allowed us to familiarise with our data, have our first impressions, be actually aware of the multiple categories that existed and have an idea of the content that was contained in the interviews. It was the base which allowed us to start working towards our theory.

4.2 Axial Coding

After finishing the Open Coding, according to the Straussian Grounded Theory, the next step is to do Axial Coding, which is the process of looking at our categories, sub-categories and codes, and looking for the existing relationships, seeing how they relate to each other, and representing them.

For our Axial Coding, we decided it would be better if we used the categories that resulted from the open coding instead of singular codes or sub-categories, since it would give the most effective presentation of it, and have the best readability. We decided to do a diagram, where categories are represented by rectangles with the name of the category, and the relationship between them are oriented arrows, where the origin category is the one that affects the category at the end of the arrow. For each relationship, there would be an identifier which started with the letter "P" (of proposition), followed by a number, which meant to allow us to keep track of the propositions of the relationships, which are how a category affects another.

A visual example of the possible configurations for a relationship is represented in the [Figure 4.1 – Possible Configurations of a relationship](#).

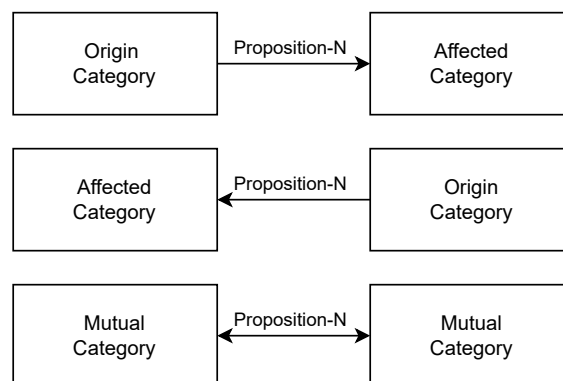


Figure 4.1: Possible Configurations of a relationship.

The process to find our relationships was an iterative process, where we started by randomly selecting a category to find its relationships. For each of its sub-categories, we would read its name to see if there were mentions of any other categories, or possible relationships. In case there was, we would create a new relationship, with a proposition based on the category and sub-category name, and assign the direction based on the proposition (uni-directional, where the starting category affects the ending category, or

bidirectional, where categories affect each other). In case relationships were not found in sub-categories, we started looking at the codes. Like we did for sub-categories, for codes we looked at the names to see if we could find mention of other categories, but at the same time we paid some attention to the quotes associated to the code, since they could contain mentions of other categories that were not taken into account. In case a code was found, the same process mentioned before would happen, where we would define a relationship, its direction, and a proposition based on the code. After finishing a category, we moved to another category to reiterate the same process.

A more specific example of how the whole process happened together with the creation of the diagram is the following: We started by choosing a single random category, which was Working Space. In that category, we analysed every single sub-category in it, and looked for sub-categories that were related to other categories. When we found them, if the category did not yet exist in the diagram, we would create a new rectangle with its name, and connect them. We would then create a new proposition to explain the existence of the relationship. We also checked every single code to guarantee that there were no missing relationships. When we finished checking every single code for Working Space, we repeated the same process for every other single category. In some cases, we found some dead-ends when adding new categories, where no new category would show up in a code despite existing. This would mean that these categories mostly influence other categories, but are not influenced by others. As such, we added them manually to the diagram and repeated the process.

Let us consider a more detailed example of how we looked for relationships inside a category: For the Knowledge Sharing category, we started by looking at every single of its sub-categories, looking for mentions of other categories that possibly are related to it. In this case, none of the sub-categories referenced other categories, so we started verifying the sub-categories' codes. When looking at the codes, for each one, we looked into their names to find mentions of categories, but also try to find them on quotes in case they are not explicit. From this, we were able to find a relationship through the code "Documentation or Wiki as Knowledge Sharing", which mentions that technologies are used to assist the knowledge sharing process. As such, we created a new uni-directional relationship between the categories Technologies and the category Knowledge Sharing, with Knowledge Sharing as the starting node, and with the proposition "Knowledge Sharing makes use of Technologies".

For the Axial Coding process, we considered any relationship despite the number of people reporting it, since during the Selective Coding we will review the codes and relationships.

During the Axial Coding, we found some issues on how to represent the notion of time, and how it affects the relationships and categories. In the multiple attempts we tried to find an optimal representation (repeat categories in different timelines, colour coding, among others), the diagram ended up being overly complex and hard to read, as it generated a lot of new relationships and presented duplicate data. Since this research

focuses on software developers’ productivity during the pandemic, we decide to redirect our focus of our Axial Coding into all the codes that occurred during the pandemic. We had several categories that were mostly exclusive to the post-pandemic, and we decided to remove those from the Axial Coding diagram, which simplified the diagram.

One of our categories, “QA and Testing” did not have any relationship with any other category, and we did not have enough QA Analysts interviewees to gather conclusions about the impact of the pandemic, we decided to remove it from the Axial Coding diagram. Upon looking at the “Lockdown” category, we found also found no connection with other category. Unlike the prior category, it was something that was experienced by the whole population of our research, and possibly were affected by the several Lockdowns. As such, we decided to create a special relationship, where it relates to and affects all the other categories.

As for the Manager category, we decided to focus on the codes that refer to what managers actively did that influenced software developers, and leave the codes about observations on their teams for discussion.

We decided to not include the CEO category since we were not able to interview more than two, and the codes that resulted from both interviews found themselves in different perspectives, and thus, not resulting in a pattern that can be used by Grounded Theory.

The final result of this process was a diagram with 31 relationships and 17 categories, which can be found in the [Figure 4.2 – Axial Coding Diagram](#).

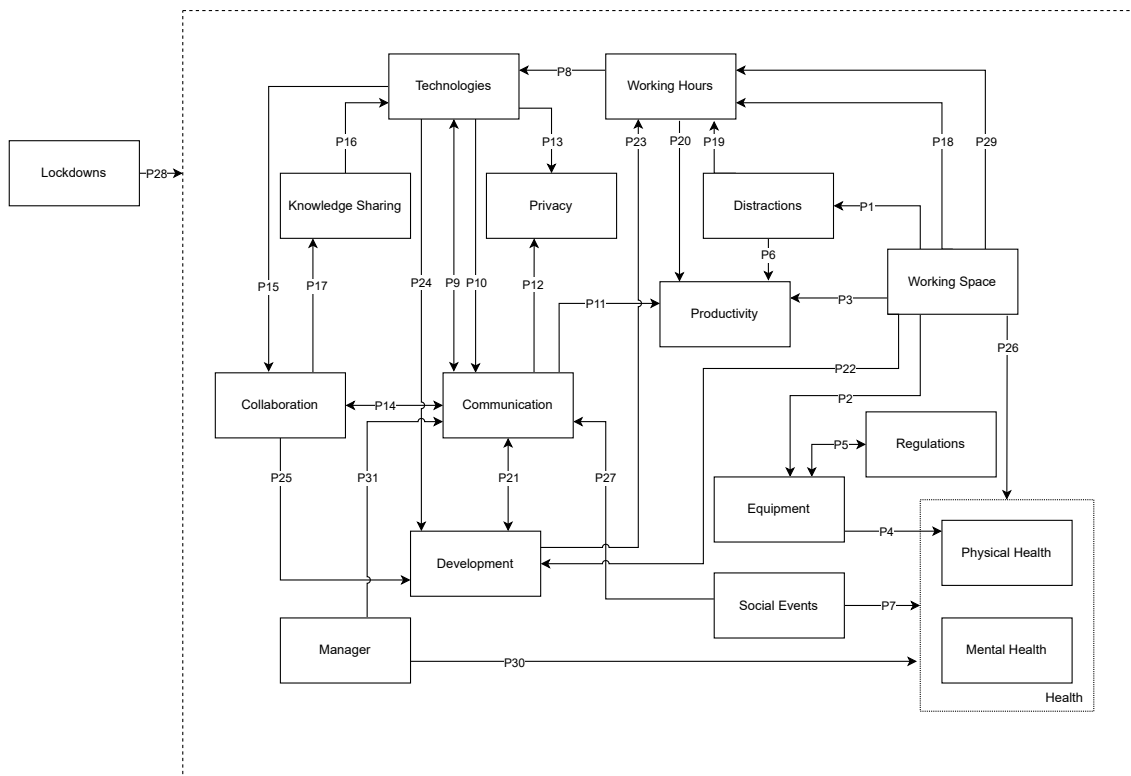


Figure 4.2: Axial Coding Diagram

4.3 Selective Coding

Selecting coding is the process of reviewing the data, while also trying to find the core category of the theory. The reviewing of the data is done by looking at the categories, sub-categories, codes and relationships, and comparing them with the objective to understand if it makes sense for them to exist and to be part of the category, while finding the core category implies looking at our data and finding a core category that is able to answer our research questions and that best fits to represent the theory.

The selective coding was done simultaneously with both Open and Axial coding. While finishing the process of Open Coding, with most codes and categories found, we would compare them to the already existing ones, and asked ourselves if the code we found made sense, if there were duplicates, if they were too specific, among other questions. This would lead us to refactoring multiple codes and categories to find the codes, subcategories and categories that best represented our data, while also maintaining the most important data. In some cases, we found that some codes did not make sense by themselves or were out of context. As such, we would merge codes that were similar or had a similar context, while in other cases we found that some codes were actually not codes, and were removed.

An example of how we did the selective coding during the open coding process is the following, for the distraction category: From our initial open code, we found four codes about distractions: *“Adults as a distraction”*, which refers about distractions caused by adults in the same household, *“Animals as a distraction”*, that mentions that animal require attention while working at home, *“Noise as a distraction”*, that can come from the street, inside the house or even online meetings, and *“Help with online classes as a distraction”*, which refers to parents having to help their children with online school. At first glance, all the four codes refer to a common theme: distractions, and who/what causes them. As such, initially, all four codes were grouped into a single sub-category, *“Types of distractions”*. But when looking more into detail, we asked ourselves: what is the cause behind each of the distractions? When looking at the first code and its quotes, we see that the distraction can be as simple as someone from the family talking with the person (*“Sometimes my mom comes here to talk (...) sometimes we chit-chat a bit and I get a bit distracted.”* [0]), but upon taking a step back, we see that this happens due to people being unable to leave home during the pandemic and having to share the same physical space. For the other codes we reached a similar conclusion that the distractions are due to the sharing of the space, and as such, we renamed the sub-category to "Distractions caused by space sharing" and moved it to the "Work Space" category.

During the process of Axial Coding, the Selective Coding took place near the end of it, after we had our diagram with all the relationships and categories. As our diagram grew with more categories and more relationships, it became very complex and hard to read, which led us to review some of the categories that we initially had from open coding. An example of this would be the *“Challenges”* category, where we found that it had a lot

of relationships with other categories, but those were mostly inherent to the categories itself. As such, the challenges could be part of the categories themselves. The “Challenge” category was then removed, as well as some relationships, which simplified the diagram.

Since we previously had considered any type of relationship despite the number of people reporting it, in this phase we took our time to look at our relationships and understand which ones made sense, which ones could be simplified, and also look at the total of reports for each relationship with more attention. As a result of that, we found that many relationships actually had only one or two person reporting, and were not the majority. Some of those cases were actually contradicted other relationships, and it was extremely important to deal with this issue to have a clear, simple way to understand our theory. Our first step in dealing with these cases was looking at the codes and categories they belonged to, and understand what the code really meant, and if there were others similar. In most cases, we found that there were no similar reports to the code(s), and as such, their relationships were removed from the Axial Coding. As we removed these relationships, some categories ended up also being removed from the Axial Coding, since they had no relationships with other categories.

Also, as part of the Selective Coding during Axial Coding, we identified that while the Manager category had relationships with other categories, the codes of the relationship were actually part of other categories, which led us to distribute some of its codes (for example, Manager influencing communication actually led to the codes being distributed to Challenges and to Communication). As a result, the Manager category was left without relationships and was removed from the Axial Coding. After this, we found a similar pattern on CEO despite not being present on Axial Coding, and we decided to also disperse some codes.

While looking at some of our categories and relationships with more detail, we found a category that did not relate very well to others, and gave more context to the research. This category was “Changes in Remote Work”, and we decided to remove those who are related to other categories, and leave this one for discussion.

For some of the relationships, since we found them extremely interesting and found strange the lack of mentions about them, we decided to do some additional questions about them to some of our interviewees. With their answers, we looked at our previously existing codes, to see if there were any new codes in the answers, or if they related to any of the existing ones. If they matched to other existing codes, we would add the interview identification to it, otherwise we created a new code. After doing this for all the answers, we checked again if the relationships had more mentions now, and if they did, we would maintain the relationship in the Axial Coding.

While Selective Coding took a great part during Open and Axial coding, we also did this process independently of the other codes. While not all codes will be present in the final theory, it is important to look at every single one to see the whole picture and see how they relate to each other, and see all the relationships present, and comparing it from the results of the Axial Coding. From this analysis, the core category can possibly

be found, since all the data is labelled and related to each other, and a possible pattern is possible to be found.

After this process, we were unable to find a core category. The reason on why it does not exist it is because we investigated the impact of the COVID-19 pandemic on software developers' productivity, and it turns out that in fact, there are multiple factors that affect the productivity. These factors have a very intrinsic relationship between them, and it is hard to pinpoint a single category that is responsible for single-handedly concisely causing an impact on every single interviewee, and impacting the other categories. To add to this, as previously reported, we found that every single person we interviewed lived in a very different situation during the pandemic, had different issues, which reflects in the lack of core category.

Despite the core category not existing, we are able to present a narrative from our results that is able to describe our data and answer to some of our research questions.

A THEORY ON THE IMPACT OF THE COVID-19 PANDEMIC IN SOFTWARE DEVELOPMENT

Having conducted all of the interviews, having hit the theoretical saturation, starting all of the coding phases, refining and finishing them, we concluded most of the Grounded Theory steps to find our theory. The next step is to interpret our findings. In total, our theory has 16 categories, including - Lockdown, Collaboration, Communication, Privacy, Technologies, Working Hours, Distractions, Development, Working Space, Productivity, Productivity, Social Events, Mental Health, Physical Health, Regulations and Equipment.

We found 18 relationships between the above categories. On the following subchapters we present the narrative of the impacts on the software developers' productivity during the pandemic, with examples of actual quotes of our interviews to exemplify.

The [Figure 5.1 – Visual representation of the theory](#) is the visual representation of our theory in a diagram, with the categories and relationships represented.

5.1 Categories

These are the categories that are part of our theory on the productivity of software developers during the pandemic. For each category, the codes that are part of it are described, along with quotes that justify it. The [Table II.1 – Summary of the theory's categories](#) summarises information about the categories and codes that will be mentioned.

5.1.1 Lockdown

This category is about the lockdowns that were required to contain the COVID-19 pandemic from super-spreading, and is something that all interviewees had to go through. They required them to adapt to new circumstances, and there is a single sub-category about how the adaption evolved with the lockdowns, where for example children and parents also adapted to them. E11 mentions “(...) *[after the first lockdown] it went much*

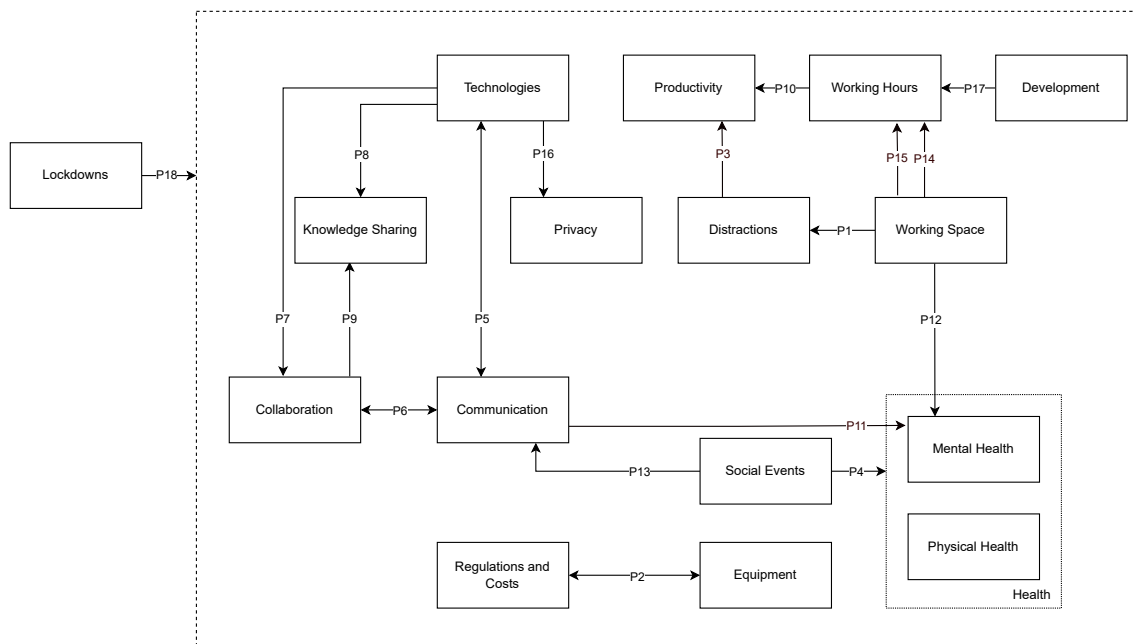


Figure 5.1: Visual representation of the theory

better anyways, not only I was more prepared, but my daughter, which is in grade school, is also more comfortable with technologies, because I never put her interacting with a computer (...)", but also most people felt more prepared after the initial one, where according to E1 "Yes, after the first one I'd say that from now forward is much easier because we know better what expects us."

Overall, the lockdowns were something that definitely affected people during the pandemic, but most people were able to adapt after the initial lockdowns and felt prepared in case others would come.

5.1.2 Distractions

Distractions were one of the biggest issues when working from home during the pandemic, whether they are caused by sharing office space, having children or living with family, according to our interviews. Multiple interviewees reported that their impact was negative on both performance and productivity, which is confirmed by E02 *"Yes, it is a very big impact on performance and productivity."* But, we got some report of people that were able to adapt or solve these distractions by making people aware of this issue, as told by E06 *"(...) I never had problems thankfully, everybody where I live thankfully respects each other's time and space, and so I was able to work comfortably in a little space that I got precisely just for work."*

5.1.3 Collaboration

Collaboration is something that was strongly present in most of the interviews and that played a huge role during the pandemic. We found that during the pandemic, the collaboration was done in three different types:

- Asynchronous collaboration - The collaboration can be done while the other members are offline, and does not require them to attend it. An example of this is Email, Wiki pages or Git. The example given by E18 was *“(...) we have communication totally async like Wikipages, email and that kind of stuff (...)”*.
- Semi-asynchronous collaboration - It occurs when the collaboration can be done through a medium where the other member can respond in real time, or later, if the other member so chooses. The best example for this are communication tools such as Teams or Slack, as mentioned by E18 *“So there’s the basic, we have the written communication semi-asynchronous, like Slack (...)”*.
- Synchronous collaboration - It happens when two or more people are interacting in real-time. It is usually related to meetings and calls through tools such as Zoom, Teams or Slack. An example was given by E10 *“If anyone needs help, we make a call on Teams, we share our screen if it is necessary to see code.”*

A relevant information is that the collaboration tools crosscut the whole company, as said by E6 *“In the same way that Mattermost is transversal to the whole company lets say (...)”*. There were also mentions of the usage of non-official communication tools for more informal and day to day talk, such as Discord, which was mentioned by E3 *“(...) we use Discord to sometimes give company to each others, when it is needed to talk and say day to day things (...)”*.

5.1.4 Communication

Communicating with others was extremely important during the pandemic and was mentioned a lot. Regarding how the communication is done during the pandemic, we found that the types of communication are very similar to the ones found in collaboration:

- Asynchronous – Communication that does not happen in actual real time and there will be a delay. An example of this would be an email exchange. As told by E17 *“Focus on the asynchronous, a lot more, and we were not used to that, and now it is much more asynchronous (...)”*.
- Semi-Asynchronous – The communication can happen both in real-time and with a delay. For example, two people can communicate in real-time in a chat, but one of the participants can send a message and only receive an answer hours later. As explained by E17 *“The communication is now done more often through Slack, in terms of warnings or draw attention (...)”*.

- Synchronous – Communication that happens in real-time and acts as a conversation. An example of this would be a video call. As noted by E17, “(...) *I think that with the pandemic there are more Zoom calls (...)*”.

We also found that collaboration and communication regularly intertwine themselves, since they share the use of the same tools, and they can happen concurrently, since to help someone it is usually necessary to communicate with them to understand the issue, and collaborate together to find a solution.

Something that we observed was the importance of communication during the pandemic for one to be able to do their work, as experienced by E14 “(...) *I am at home at permanent contact with people of my team, and others teams, that yes was particularly important (...)*”.

We found multiple reports that remote work made the interviewees feel more socially distant from their colleagues or other teams, as experienced by E17 “(...) *after a while people started to feel a bit more distant during the pandemic(...)*”.

About the tools used to communicate during the pandemic, there were mentions about dedicated spaces for communication being created and used, whether they are for leisure or work, as reported by E3 “(...) *we have a variety of channels that are divided, for example, we have team-general, a chat for engineering, one to talk with data science (...)*”. The company-wise usage of tools is also mentioned, quoting E6 “(...) *Mattermost lets say that it is transversal to the whole company (...)*”, which facilitates the internal communication among teams.

Finally, about the Internal Communication, which refers to the communication between the company itself and its employees during the pandemic, we found that surveys were done to assess the well-being of employees during the pandemic, as reported by E8 “(...) *we did a first survey, a survey transversal to the whole company with a series of questions on how people were feeling, if they felt like they were performing as before, just to have an idea of the questions, if they felt like their productivity had increased or decreased, if they felt any difficulty (...)*”.

5.1.5 Working Space

For our Work Space category, we want to start by focusing on those who had to work in person during the pandemic. We had several interviewees who fit in the description, and according to them, this happened in-between lockdowns, when offices were open, as stated by E17 “*Yes, when offices started to open, somewhere between July and august, we would go [to the office] one or two times per week to socialise with the team.*” The motives for this included interacting with other people and accessing systems that are unavailable outside the office, among others.

Since this was during the pandemic, it is important to understand what measures were taken to avoid the COVID-19 infection, and our interviewees mentioned that the mandatory usage of masks, having at least the minimum distance of 1.5m between each

other, which E2 experienced “(...) *we were separated, we have a gap between us in the desk, and all of us use a mask inside the office (...)*”, that there was a limit to the number of people inside a room, “*All of the rooms had a limit of number of people who would be inside it (...)*”, and that a kit for cleaning of the personal desk was offered “(...) *they gifted all of us a personal hygiene and cleaning kit, with a mask and disinfectant (...)*”, both of which E6 experienced.

When working in the office during the pandemic, among the ones who did, some felt discomfort, mostly related to the characteristics of the pandemic itself and its transmission, as it was the case for E6 “(...) *I felt very uncomfortable in terms of having to use the mask essentially during the eight hours that I am in here (...) during the lunch time it was another moment where I did not feel comfortable (...)*”.

Overall, working at the office during the pandemic had its share of drawbacks, and it affected negatively the experience and work of those who did it.

Moving on to the working from home space aspect, we found that there are three type of work spaces when working from home:

- A separated but not dedicated work space - A space that is mostly only used by the interviewee, where work is done, but can also be used for other activities. An example of this would be a bedroom, where one can work, sleep and do leisure activities. E18 told us more about this model, “*More or less, I work in my bedroom, in the place where I have my leisure computer, so the computer that I use to game, and it is on that desk that I work, I do not have a dedicated office for me in this house.*”
- Dedicated work space - A space that is separated from the other rooms of the house/apartment, and it used exclusively for work. These can be shared or not, and the best example would be a home office. E10 was able to experience this, “*Yes, I have a room that is an office.*”
- Neither dedicated nor separated space - A work space that is used for multiple activities, and is shared with other people. For example, a living room, as E7 reported “*Not properly, I use the living room [to work].*”

From our data, most of the interviewees either had a separated but not dedicated space, or a dedicated space, with neither dedicated nor separated space being the minority. Out of our twenty interviews, only two people lived completely alone, while the others shared house with family, friends or partners.

A lot of distractions are caused by the sharing of space - whether it is work space or the house itself - were reported. The most common one is distractions caused by other people, whether it is due to a conversation like E0 “*My mom sometimes comes here to talk (...) sometimes I give her a bit of talk and I get distracted.*”, or due to children, like E11 said “(...) *while I was working at home she was at home, typically she had online classes, and she is on the third year for the first time, I had to help her with online classes (...)*”. Something that was also mentioned was noise causing distractions when working, whether it was caused

by the environment or other people, as experienced by E7 “(...) *a random background noise, or if people are talking, that immediately makes a bit of interference.*”

We found that the biggest challenge when working from home is the difficulty one has when trying to separate working space from leisure, both mentally or physically, and this hardship ends up affecting one’s work negatively, as told by E1 “*But that was something that I felt that was harmful, not having that space well, it was not as easier to separate work from other tasks, and maybe it put a bit of a mental barrier to really stay inside the work mindset.*”

In our interviews, we found mentions of how the remote work has the benefit of decentralisation, where cities become less overcrowded and with less traffic, as observed by E3 “(...) *and it does not create the overcrowding that we have at the moment in big cities like Oporto and Lisbon, where the prices of houses are rising like crazy, there is hellish gigantic traffic (...)*”. The reduction of traffic has another benefit, since people spend less time commuting to work, and in turn, have more personal time, as told by E0 “*It increased a lot the personal time, because I would have to do home tasks either way, I end up saving commuting time and at lunch I still have time to do some things after.*”

While working at home has its benefits, as we just saw, it shares some of its drawbacks with its counterpart, working in office, due to the working space. Those who do not have a dedicated and separated space are prone to distractions from others, but it is easier to address those distractions when working from home.

5.1.6 Equipment

With the start of the pandemic, not everyone had experienced remote work and had the necessary equipment for it, and possibly had to acquire it. According to most of our interviewees’, companies provided the necessary equipment for working from home, quoting E14, “(...) *besides that, the company in particular allowed and encouraged people to get the equipment they needed from the office (...)*”. In total, six people reported that the company was open to help monetarily, as it was the case for E9 “*My company gave a voucher of value X to its employees if they wanted to buy a more comfortable chair, a decent desk, which helps (...)*”, and four interviewees reported that they had no help from their company, as stated by E4 “*No [they did not help acquiring equipment], although it gave me a monitor and a laptop, besides that no*”. Five of our interviewees bought office equipment during the pandemic, such as an office chair, a new desk or computer peripherals, as E10 noted “(...) *I bought a better chair, a new keyboard and a better mouse (...)*”.

Overall, the equipment played an important role during the pandemic, since it was something necessary for people to work, and required people to adapt their spaces for it, thankfully with the support of their companies.

5.1.7 Knowledge Sharing

Knowledge sharing is the activity of sharing knowledge within the same organisation, with other teams or colleagues, in order to keep multiple people and/or teams up to date regarding a certain matter. According to our interviews, there are three types of knowledge sharing that can happen:

- Presentations and meetings – Meetings which involve multiple people and/or teams, surrounding the presentation of a specific theme, as said by E6 *“Yes and during the pandemic we continued doing our presentations, and stuff that we also had, so yes, it continues.”*
- Asking and solving questions – When one member has doubts about a certain matter, and one or more colleagues share their knowledge about it, as noted by E7 *“(…) if any kind of problem exists, we help each other, to correct that stuff and be able to advance (…)”*
- Usage of technologies – Technologies can be used to share knowledge, allowing one to document it, so that others can read, as referred by E18 *“(…) there has been a bit more of effort to have more written documentation (…)”*.

From our interviews, the majority of the interviewees reported that the knowledge sharing sessions happened regularly during the lockdown stages of the pandemic, but instead it has moved to an online format, as mentioned by E18 *“Yes, it is done more or less in the same way it was done in office, but in a digital way (…)”*. We found multiple reports on how sometimes other teams (whether they are development teams or not) participate in these sessions when required, as reported by E16 *“No, normally when we need someone to transmit us knowledge is when we call the person, but it is not always.”*

Some changes reported in the knowledge sharing process is that it requires more logistics and more preparation to do so. E3 shared *“Maybe it is a bit harder because it requires more logistics to share that stuff (….) here we have to make a call, make a share, only one person at a time can share, so it is a bit more rigid in that aspect.”*

We had reports of the impact of knowledge sharing during the pandemic, which was generally positive, as it allows people to unlock situations and move forward more easily, as E17 said *“Yes, because the better knowledge sharing is, the better it is for people to unlock all the necessary context, because there it is, since the pandemic impacts a lot the interaction with people and asking for help, if people have all the knowledge they need and are able to advance alone, that is always the best.”*

Last but not least, we had some interviewees commenting on how knowledge sharing is always important despite the context, because it benefits everyone and allows everyone to be up-to-date with the knowledge, quoting E7, *“I think despite working remotely or not, the impact would be the same, because in both cases it is good to have feedback between all of us, know what is going on, where we stand, so that we can move forward (…)”*.

5.1.8 Health

Health has been one of the biggest concerns during the pandemic, not only due to the nature of a pandemic, but because during lockdowns everybody had restrictions about leaving home and interacting with other people. As such, we found in our interviews two categories, Mental Health and Physical Health, which played a big role during the pandemic.

5.1.8.1 Mental Health

From all of our interviews, there is undoubtedly an issue that almost everyone agreed to and is the main concern of mental health during the pandemic: the burnout. Burnout is a work-related stress where one feels exhausted, resulting from excessive and prolonged stress.

We found that regarding this topic, most people reported that during the pandemic and when working remotely, they felt more vulnerable to the risks of burnout for diverse reasons, such as the pandemic context, as is the case for E11 *“Without a doubt [it is easier to hit burnout], I think there’s also a whole outside context that I felt in both the first lockdown and in the January one, where with the COVID-19 cases rising affected a lot my concentration in a lot of moments, there was a fear factor associated that affects us and might [more easily] lead us to burnout.”*, but the biggest reason that was reported for this was having a hard time separating working from leisure while working remotely, and how the lack of routine could lead to burnout, as explained by E6 *“I think so because I think to avoid burnout it is necessary to have a change of scenery, and the easiest way for that is to change space, and without being able to leave home, that’s more complicated (...)”* and by E0 *“(...) We no longer have that routine where we have to prepare ourselves that what we are doing is working, and then no longer it is (...) and now that everything is done in the same space, (...) where it is leisure or work, (...) everything looks the same (...)”*.

Another issue that we found related to the mental health is how social isolation has a negative impact in it, and how that made it more difficult to adapt to the pandemic, as experienced by E12 *“(...) the biggest challenges were being able to adapt to always remote without having to talk with people (...)”*, and how they felt more lonely, as said by E14 *“(...) I was closed at home, working in front of the computer, I would not see anyone because I did not have regular calls (...) I ended up being very lonely (...)”*.

Since these are serious concerns that can affect one’s mental health, and in turn their work, we looked into what companies tried to do to address this issue, where most people reported that their company provides psychologist sessions, or provides a health insurance that includes it, as mentioned by E4 *“The company provided the conditions for a health insurance to its employees, and in that insurance that is contemplated, yes.”* Besides that, companies also provided meetings and initiatives regarding the mental health, where multiple topics about it are discussed, and ways to deal with some problems. As said by E13 *“A lot, it promoted a lot but really a lot of workshops, seminars that were presented*

by people from the mental health area, with a questions and answers segment, about several themes, whether it was about distance, virtual collaboration, burnout, what is working remotely like, so a lot of different themes, all associated to this that [mental health] main topic.”

We asked our interviewees if they think it was important for companies to provide easy access to psychologists, from which the majority answered that they found it relevant, as said by E6 “(...) *I think that any company should also care about the health of its employees, because if someone feels good, both mentally and physically, then a person can work better and be happier in the company.*”

Last but not least, working remotely also brought some benefits to the mental health, such as less stress due to the lack of traffic, as reported by E4 “(...) *I know that it is something that for a large part that facilitates a lot on the employee side, since I do not have to be stressed with the traffic (...)*”, and that they have more well-being when working from home, which has a positive effect on their work, quoting E6, “(...) *it has a big advantage, since I do not have to go there, I end up waking up later and have a more rested sleep, I am able to eat breakfast with whom I live with, and I end up having a more relaxed morning, a lot less stressed, and when I sit to start working I feel more energetic and ready to develop (...)*”.

5.1.8.2 Physical Health

During the pandemic, the physical health was also a big concern, since one spent less time moving and exercising was more restricted. As such, companies tried to help on distance, with for example online exercise classes, as reported by E4 “(...) *an online physical exercise class, where everyone gathered on Hangouts, with the webcam turned on or not, there were some people who did opt to not do, and we had exercises to do (...)*”, or social events outside of lockdowns to increase the well-being, as noted by E3 “(...) *there was a house party that followed the COVID-19 prevention norms (...) we spent two to three days socialising in a house paid by the company (...) and it was also to have a bit of team building, but also to relax and chill.*”. But, for half our interviewees, their companies did not meet their expectations about the promotion of physical health, as explained by E6 “*No no, the maximum they did was basically launching a little web page to help people adapting to remote work (...) it was not very helpful (...)*”.

5.1.9 Working Hours

With the sudden change of the working space during the pandemic, the working hours also had to adapt and change to the new reality, since people started working from home and did not spend time on transportation to work.

First and foremost, from our interviews, we had several reports on changes of how the working hours changed, with some people reporting that they were doing more hours, either because they felt motivated about their project, as noted by E3 “(...) *sometimes I stay a bit longer working because I want to solve a problem, and I’m more motivated, for example because it is a project that interests me (...)*”, or because not having a separated space leads

to work more hours, as told by E9 *“More, because I have the laptop near me, (...) a lot of the times I’m laying down on bed, looking at the television, and thinking «I could be using this time to quicken some work» (...) so I grab the laptop and start working, so I end up working more hours.”* Other than that, we found that the way some of our interviewees’ working hours slightly changed, where they would work more, but they would also have days where they work slightly less, which ended up in the same amount of hours pre-pandemic. As said by E15 *“I think that it was more or less the same amount of hours, like I said before, on one hand I would do more hours, but on the other when there was not as much work I would work less hours, so it was more or less the same.”* We also found that some of our interviewees have working hours exemption, and as such have a flexible schedule, as explained by E16 *“(...) the working schedule always was very flexible, the only thing that holds us to the calendar are meetings and some synchronisation processes, but was always flexible, and still it (...)”*.

A topic that we covered during our interview was timesheets and how they changed with the pandemic, from which found that these are mostly used to understand effort allocation, understand how much time one spends in a task, as said by E1 *“(...) timesheets help more understanding how much time you spend in each task, and where really is the effort of the team (...)”*.

5.1.10 Skills and Technologies

With the pandemic environment, companies had to adapt to the new reality and adopt technologies that fitted the situation, as well as their employees. We found several interviews that had to learn new technologies for their work, such as communication technologies or environments. As said by E5 *“Yes [I had to learn], before we did not use Zoom and now we do, it is the only difference”*.

Outside of the work, most people did not try to learn any new skill or technology that are not related to their work, with lack of time being the main reason, as noted by E7 *“Not really, because I do not have a lot of time to do it.”* But a few people actually took advantage of the pandemic to learn new technologies, as explained by E10 *“Yes, outside of work I started developing things in Kotlin, which I do not have the necessity to use in the company, I started using Java to relearn and that’s it.”*

5.1.11 Productivity

Productivity of a software developer is the main concern of the research, and as such it is necessary to understand how it changed during the pandemic. From our interviews, the majority of the interviewees had an increase of productivity when working from home, as experienced by E16 *“It was positive, I was getting annoyed with not being productive enough some days [in the office], and at home I feel much more productive, and I can organize the day more my way, and I feel like I can produce way more (...)”*, and more specifically not having to travel to work contributing a lot for this increase of productivity, quoting E1, *“I can say*

for example the fact that I do not have to travel to work and worry about leaving home to do my stuff affected my productivity positively (...)”.

We found that the people whose productivity was most negatively affected from working remotely were parents, since children were at home and are dependent of parents, requiring their attention and care, as noted by E8 “(...) *mainly some attention to people with children, how they were dealing with that, because at that time online school was also starting, and depending on the children’s age, it can be really stressful (...)*”.

We also found mentions on how their productivity is measured in their company, which mostly is done indirectly, based on the tasks done and the value added, as explained by E3 “(...) *it is done an assessment in the sense of, for example performance evaluation, but what is measured is the value added, instead of productivity itself (...)*”, and in some cases this is done yearly, as is the case for E4 “*Yes, it [productivity] is measured in my company, the performance evaluation that we have are done yearly (...)*”.

5.1.12 Social Events

With the pandemic and lockdowns, social events could no longer happen in person, and as such they started happening online. From our interviews, these online events can be for example virtual coffees, as noted by E10 “(...) *for example sometimes we would each one take some snacks, each person took whatever they wanted to eat, a beer or a cider or whatever, and we would be there chatting like we were at a coffee shop, but each one at their own house(...)*”. We had mentions of these social events being incorporated as part of meetings, as told by E3 “(...) *on our meetings where we analyse what happened during the week, there is a space more dedicated to educational games and things like that, not only to get to know each other in our team, but also to relieve a bit of the pressure (...)*”, which is related to another mentions that we found about these online social events being used for team building, as experienced by E14 “(...) *there were also some team building events, not long ago a colleague changed to another team and in the farewell moment he organised a team building event (...) so there was a kind of online event where we all shared information about ourselves to create some kind of knowledge between the people of the team.*”.

The biggest benefit reported in our interviews for the online social events was allowing people to be closer at a time that it was hard to, as explained by E4 “(...) *they always help in the sense that there is maybe more contact with people that you cannot have with, at the time you could not be so close of people (...)*”.

As for the impact of online social events during the pandemic, the majority of the interviewees reported that they helped adapting to the pandemic, by giving the necessary social engagement, as experienced by E18 “*They helped me having contact with people, which is something that not everyone needs, but here is a lot of people who need the social factor and feel engaged, which is something hard (...)*”, maintain social connections and allow new employees to create connections remotely, as noted by E16 “*Yes, I think so, essentially they helped not losing connection with people who I already worked with, and since the teams*

recently changed, there was a lot of new people, and it helped to create some kind of connection that otherwise would be non-existent.”, and finally it helped giving more context about what was currently happening in the company during the pandemic, as explained by E15 “Yes, they helped me understanding more the enterprise context, they helped me having some idea of what was happening in the company, because otherwise I would be much more focused or in my corner doing my work, without knowing the impact of the pandemic on the company, so it helped in that perspective.”

5.1.13 Development

To better understand how the software development was affected, we have to look at what type of developments are done. The majority of the software developers we interviewed worked with the Agile methodologies - such as Scrum, which is composed by several processes. As explained by E14, “(...) beyond that, on a methodological view point of the organisation of the team, we still are making the same ceremonies, we keep working in scrums, we keep having the same kind of project evaluation meetings, of estimates, of retrospectives, of reviews (...)”. Another kind of development also mentioned was the solo development – when one develops most aspects of a project alone, end-to-end, as experienced by E11 “I always worked very much alone, practically alone in my team, so I end up doing all the process, it is done by me (...)”.

As for the development changes, the majority of the interviewees reported that there were no significant changes to the development process, since it is very similar to what it was pre-pandemic, but now in an online format. Quoting E0 “It did not change much since the pandemic happened, it is still the same things but on another format (...)”.

Regarding the impacts of the COVID-19 pandemic on others teams, and how those impacts affect the development teams, the majority of our interviewees mentioned that the impacts on the other teams did not impact at all the development. As said by E4, “I think that the impact of the others teams on mine, in terms of operational processes, I do not think it had any effect.”

Overall, the software development process was not affected a lot by the pandemic, as it barely had any noticeable changes.

5.1.14 Privacy

With the working from home and online meetings, privacy played a big part. But, according to our interviews, most of the interviewees did not feel their privacy compromised by remote work, either because the company does not control them, as explained by E6 “No, at all, I never had that problem, no one from the company said that they wanted to control what am I or not doing, what I am using, I never had that problem at all.”, or because they had their own control on their privacy, as said by E3 “No [I do not have less privacy], because I insist on only turning the webcam only when strictly necessary.”.

We also found that technologies help in keeping some privacy, as believed by E4 *“Although I believe that the existing technologies allow to help in the preoccupation that is the privacy when someone is working from home.”*, for example, background-removing technologies, as explained by E9 *“(…) Teams removes your background, so they cannot even see your room, it looks totally blurred, wherever you are (…)”*.

Overall, most people did not feel like they had less privacy when working from home.

5.1.15 Regulations and Costs

The costs have been a subject mentioned a lot during the pandemic, since when working from home, one uses more of its own resources. From our interviews, we also found mentions of this consumption increase, which in turn increases costs, whether it is electricity or other resources, as mentioned by E2 *“And the electricity also increased a bit because I was at home using my resources, which did not help.”*

But, we had mentions about this increase of these costs being compensated by the transport allowance, since when working from home these would no longer happen, as mentioned by E1 *“(…) the truth is that the company also gives a transport allowance, and at the moment no one is using it, so one thing ends up compensating the other (…)”*.

5.2 Relationships

With our categories presented in the previous subchapter, we can present the relationships that exist among them and explain them. For each of the relationship, we present its proposition, its category and sub-category, code(s) in case it is related to specific code(s), and a brief comment explaining the relationship.

Table 5.1: Relationships between the theory categories.

P1	Shared space causes distractions (Space → Distractions)
Category	Working Space (Distractions caused by sharing space)
Comment	As we previously saw, when working remotely and sharing space with other people or animals, it causes distractions to one’s work.
P2	Companies helped acquiring equipment, and equipment was acquired with help (Regulations and costs ↔ Equipment)
Category	Equipment (Equipment Acquisition)
Code(s)	Company made available monetary help for equipment costs; Bought equipment during the pandemic.
Comment	Companies provided the necessary equipment for remote work, and some of them even paid for the costs of new equipment. On the other hand, interviewees acquired some equipment, either lent from the company, or bought with the company’s help.
P3	Distractions affect productivity negatively (Distractions → Productivity)

Table 5.1 continued from previous page

Category	Distractions (Impact of Distractions)
Code(s)	Distractions with a negative impact
Comment	The distractions that occur in the working from home context have a direct negative impact on developers' productivity.
P4	Social Events for health promotion (Social Events →Health)
Category	Mental Health (Mental health promotion); Physical Health (Physical health promotion).
Code(s)	Social events outside of lockdowns to promote well-being; Meetings and initiatives about mental health.
Comment	The promotion of health was done through social events, such as online exercise classes, meetings outside of lockdowns, or workshops about mental health.
P5	Usage of technologies and tools for communication, and communication done through technologies (Communication ↔ Technologies)
Category	Communication (Technologies for communication)
Comment	With the pandemic, the communication between colleagues and teams changed to an online format, which makes use of tools and technologies.
P6	Communication occurred as collaboration and vice-versa (Communication ↔ Collaboration)
Category	Collaboration (Types of collaboration); Communication (Types of collaboration).
Comment	The collaboration and communication happen at the same time, and make use of the same tools.
P7	Usage of technologies and tools for collaboration (Technologies →Collaboration)
Category	Collaboration (Types of collaboration)
Comment	With the pandemic, the collaboration between colleague and teams changed to an online format, which strongly makes use of technologies and tools to share information.
P8	Knowledge Sharing makes use of technologies (Technologies →Knowledge Sharing)
Category	Knowledge Sharing (Types of Knowledge Sharing)
Code(s)	Tools and documentation as knowledge sharing.
Comment	Knowledge sharing during the pandemic makes use of technologies to store information, to be accessed later.
P9	Knowledge Sharing through collaboration (Collaboration →Knowledge Sharing)

Table 5.1 continued from previous page

Category	Knowledge Sharing (Types of Knowledge Sharing)
Code(s)	Knowledge sharing through meetings and/or presentations.
Comment	Knowledge sharing during the pandemic is done through collaboration with others, to present and pass on information.
P10	Timesheets help understanding effort and productivity (Working hours →Productivity)
Category	Working hours (Timesheets usage)
Code(s)	Timesheets allow to understand effort allocation.
Comment	Through timesheets, one is able to understand the effort used to realise tasks, and their productivity.
P11	Lack of communication has a negative impact on mental health (Communication →Mental Health)
Category	Mental Health (Negative impacts on mental health)
Code(s)	Isolation has a negative impact.
Comment	The lack of communication with other people during the pandemic, and social isolation, have a negative impact on the mental health.
P12	Lack of space separation worsens Mental Health (Working Space →Health)
Category	Mental Health (Burnout during the pandemic)
Code(s)	Difficult separation of telework and leisure facilitates burnout.
Comment	Working at home during a pandemic (and thus being restricted on leaving home during the lockdowns) has a negative impact on mental health and facilitates the burnout.
P13	Social Events benefit communication (Social Events →Communication)
Category	Social Events (Benefits of social events)
Comment	Online social events allowed to approximate people when there was a lack of in person communication, and had the benefit of avoiding social isolation.
P14	Working space increased Working hours (Working Space →Working hours)
Category	Working Hours (Changes on Working Hours)
Code(s)	Having the work computer in the same space as leisure makes one work more hours.
Comment	Due to not having a physical separation between work and leisure, one can have an hard time separating working hours from leisure works, and ending up working more.
P15	Relocation increased personal time (Working Space →Working hours)
Category	Working Space (Decentralisation as a benefit)
Code(s)	Less time wasted on commuting to work.

Table 5.1 continued from previous page

Comment	When one works at home and does not have to commute to work, it ends up using that commuting time as personal time.
P16	Tools and technologies help increasing privacy (Technologies →Privacy)
Category	Privacy
Code(s)	Tools help with privacy.
Comment	Communication tools have technologies that help at increasing one's privacy in the context of working at home.
P17	Motivation in development increases working hours (Development →Working Hours)
Category	Working Hours (Changes in working hours)
Code(s)	Motivation or project increases working hours.
Comment	When working remotely, one can work more hours simply because they feel motivated about the current software development.
P18	All of the categories happened in the context of the pandemic, and most during lockdowns (Lockdown →All categories)
Comment	Most of the categories and relationships mentioned happened in the context of pandemic and lockdowns, and is responsible for all the changes.

Having presented the relationships, we are able to look at them with more details and see how they relate to each other.

From the proposition P1, we know that shared space causes distractions, either because of other people, or due to noise, and from P3 we know that distractions have a direct negative impact on productivity. Then, if a shared space causes distractions (P1) and distractions have a negative impact on productivity (P3), the working space has an indirect negative impact on the productivity.

According to P11, the social isolation has a negative impact on mental health, and from P13 we know that social events benefit communication between colleagues. Both of these relationships together confirm the effects of the proposition P4, that the promotion of mental health through social events contributes to reduce the social isolation and avoid mental health problems that can provide from it.

We observe that the technologies and tools have an enormous importance for remote work, as communication, collaboration, knowledge sharing, as seen in propositions P5, P7 and P8. As such, it is necessary that technologies and tools are reliable and evolve according to its user needs.

While the remote work had the benefit of more personal time, as described in P15, there are a number of factors that end up increasing the work time too, such as the motivation seen in the P17 or the hard separation of work from leisure, as seen in P14. As such, these end up compensating each other, and might lead to the same exact number of hours pre-pandemic.

5.3 Validation

For the validation of our theory and its results, we used the member checking validation, which is a validation method for qualitative researches, that involves in testing the data, analytic categories, interpretations and conclusions with the original participants of the research, according to Lincoln and Guba [32]. In our case, we presented a document with our theory, its categories and relationships to our participants, asked them about their opinion, and if it made sense based on their statements during the interviews.

At the moment of writing, we were able to validate our results with seven of our interviewees. All of them agreed with the theory, its categories and relationships, as well as the different impacts found during the pandemic, and stated that it reflects on their experience as a software developer during the pandemic. We had some observations about some of our categories which ended up being incorporated into the theory, for example, we had an observation about more effort not being the equivalent to more productivity.

5.4 Limitations

While we covered most of the topics extensively, there are some limitations due to the population of the research. All of our participants are Portuguese, and most of them lived and worked in Portugal during the pandemic. As such, the theory and its conclusions only apply in the Portuguese context, since Portugal had its own COVID-19 prevention measures, lockdowns and their rules, laws and more.

Another limitation regarding the research is also about the interviewed people and the method they were recruited. Since we mostly employed the convenience sampling for recruitment, we leveraged our personal contacts, so it might not be representative of the Portuguese software development population as a whole.

There is also a limitation related to the method we employed to gather data. We only used one method for it, through semi-structured interviews, and the data gathered from it is based on personal opinions, and it is based on memory and perception of the participants. As such, they might not be in line with the objective reality.

An additional limitation is how the interviewees perceive their own productivity. Software developers individuals can perceive their own productivity in different ways, both through soft and/or technical factors, and their perception of may not always match their actual productivity.

Last but not least, another limitation it is the bias of the researcher, which is present in the way that interviews were conducted, and is related to the way the interviewer asks questions and its own identity, as it can affect how and what participants answer. The bias was also present when the questions for the semi-structured interviews were created.

THEORY DISCUSSION

Now that we have presented our theory, its categories and relationships, it is necessary to discuss the results. We divided the discussion into three pandemic timelines (pre-pandemic, pandemic and post-pandemic), where we discuss different aspects of them.

6.1 Pre-pandemic

Before the COVID-19 pandemic, remote work was already a reality, although not as frequent as it was during the pandemic. As such, it was a basis for the pandemic remote work, and it is important to look at it.

From our interviews, we found that about half of our interviewees already had experience of working from home pre-pandemic, either fully or hybridly, and the very same reported that that previous experience helped them to adapt more easily to the pandemic, as explained by E11 “(...) *I had the advantage of already being used to remote working, I was not caught unprepared one day to the other because I was already remote working one month and half prior(...)*”. This previous experience reflects in some benefits for the interviewees, but it was not enough to avoid certain clashes that happened and clearly affected their productivity. One example of this would be having to adapt to lockdowns and being restricted on where one person can go, not having in person social contact with other people, or even having children at home when remote working.

One of the comments we had about distractions were that the pandemic distractions end up replacing the pre-pandemic ones, and having similar impacts. This indicates that while the pandemic distractions are new, the impact of distractions already existed pre-pandemic, and are just occurring differently due to the context. E03 said “(...) *I think that the time that one loses while going for a walk, or eating a snack or cook the lunch, was maybe the time one would lose for example in public transportation (...)*”, and by E4 “(...) *maybe a bit of confusion also in the office, because not all offices are very controlled in terms of noise (...)*” regarding this matter. This is particularly backed up by the mentions of distractions and noise already being distractions associated to the office pre-pandemic, which were caused by colleagues, but now are simply caused by family members, background noise

and others. This is confirmed by the pre-pandemic Productivity category.

Unlike the previous categories, the Communication category contains interesting information about the pre-pandemic communication. The first one is that some communication was already done at a distance, whether it was inside the same country, with other teams, or with other countries, where tools and processes were already defined for this, as said by E14 *“(...) part of the reunions were already with remote people, we have colleagues in the United Kingdom, we have colleagues in the United States, so that was already part of our day-to-day, there were already tools, processes, and we were used to this happening (...)”*. To reinforce this, in our Technologies and tools pre-pandemic, we have mentions about the infrastructure already existing *“(...) we already had the whole structure and all the necessary material to overcome that difficulty in particular (...)”*. Something was that mentioned a lot about the pre-pandemic interactions with other colleagues it is that it was very useful, as it allowed one not only to have more context about what is happening in the company, but also understand objectives, unlock ideas and more. E15 delves into this topic *“Yes, without a doubt, it helped to unlock ideas, but also helps to have context about others’ work, their perspective about the projects, those type of informal conversations also helps us to leave our house and understand the context of our colleagues, the objectives of the company, of the project and much more.”*. Besides that, some interviews also mentioned that these informal pre-pandemic interactions helped at unwinding from work, and coming back more relaxed, which helped at unlocking blocked work. This is due to the interactions working as a positive distraction, which forces one to not think about work for a bit, and allows one to relax for a bit.

6.2 Pandemic

With the COVID-19 pandemic, the world turned upside down, and with it so did the software development area. Overnight, entire countries entered in lockdown, and companies had to adopt full remote work.

The referred lockdowns implied that people stayed restricted to their homes, and limited social contact with others. Since this was unprecedented, the lockdowns ended up affecting all of the interviewees’ lives, and their work, sometimes in a positive way, sometimes in a negative one.

During the pandemic remote work, we saw multiple distractions arising at home, mainly due to the new circumstances that the lockdowns brought, where almost everyone was restricted to their homes, and causing these distractions, whether they are caused by other people or simply background. As such, these distractions are mostly caused by being in lockdown with other people, and as we previously saw, they have a negative impact on the productivity, since one has fewer moments of focus. But, by making the people one lives with aware of these distractions and their negative impact, it is possible to reduce their impact, and is a possible solution for this issue.

The collaboration and communication have walked very tightly hand in hand during the pandemic. The reason for this is because for one to collaborate, it is necessary for people to communicate to each other, work together and share ideas. Something that also allowed these two to be very tight is that tools used for both end up being the same, with only the asynchronous ones being different. Speaking of synchronisation, the most common forms of both communication and collaboration are still the synchronous and semi-asynchronous ones, but instead of occurring face to face, now they happen fully online and through communication tools, which are usually cross-cutting to the whole company. As such, it is extremely important that these tools are reliable and fulfil the companies' needs. Something that was also observed is the usage of alternative communication platforms for informal, which helps to address the social isolation during the pandemic, and also served as team building. The communication was more affected than collaboration due to the pandemic, causing colleagues to be more distant, and making one realise how important communication is. According to managers, communication being extremely important for teams to work well when working remotely, as explained by E12 "*[it is necessary] communication, lots of space for people to discuss their ideas, and good applications and network (...)*". As such, it is important to promote communication during the pandemic, either by creating moments for people to socialise, such as social events, or spaces in the communication tools where people can interact.

With the quick change to remote work, not everybody had the necessary equipment for working, which is why the acquisition of equipment and providing help with the acquisitions was something important, as well as guaranteeing that employees have the necessary conditions to work. There were also some worries about ergonomics, which relates to the physical health, such as back pains caused by sitting for too long on a chair, wrist pains, among others. The pandemic also had some impacts on the equipment according to our interviews, which led to some health issues, as E12 declared "*(...) we had some people at home that had some tendinitis because they were not worried about having a good chair (...)*", but also increased the severity of pre-existing problems, like internet, as experienced by E0 "*(...) I changed ISP simply because Wi-Fi did not work (...)*". It is extremely important to guarantee that the employees have the necessary equipment for the remote work context, but also to guarantee that they have all the necessary conditions to ensure that they are productive.

As for the working space, it is one of the biggest reasons on why people suffer from interruptions and others, and it impacts productivity. These interruptions can be simply caused by the lack of awareness of other people, such as children and adults. We did not have much people reporting that they have children, which is confirmed by the biggest age density range in the [section 3.3 – Population](#), and as such, we have very few people saying that their children caused them distractions, mainly said by those who have children – but we had a lot of observers saying that their colleagues that have children had a really rough time during the pandemic with the responsibilities and distractions caused by children. Something very interesting was that animals were a new source of distraction, since these

were not present in the office, as said by E0 “(...) *I also have a dog, and sometimes it asks for attention (...)*”. But not all things associated with the working space are negative, not having to travel to office has its benefits - not only environmental benefits, such as less pollution and less overcrowding in cities, but also well-being benefits, like more personal time, and more rested sleep. Overall, going to the office during the pandemic seemed to have a more negative impact than a positive one, even with the COVID-19 measures in place, since those can cause discomfort, but there still are social restrictions, as well as the fear to catch the coronavirus. Regarding the office space, both CEOs said that they did not reduce their office space, but instead either retracted an expansion for the post-pandemic, or increased during the pandemic. Overall, some problems caused by the shared working space in the context of remote work can be mitigated by having a dedicated space for work, which is not always possible.

The knowledge sharing is still important as ever in the pandemic, and it occurs regularly in most cases. During the pandemic, it happens mostly in synchronous formats, through meetings or presentations. As for the participation of other teams, they are usually invited only if necessary, but in some cases they participate whether they are necessary or not. This promotes the communication and collaboration between teams and guarantee that the information is shared among a set of teams. As for the changes, it mostly became a bit more complex in terms of logistics, which is a consequence of the change to remote work and the massive adoption of communication tools. In summary, the knowledge sharing only adopted an online format, and it had a positive impact on software development during the pandemic, as it allowed to mitigate some problems by promoting communication and ensuring that everyone has the same information. But, more importantly, as said by some of our interviewees, knowledge sharing is important independently of the context, as told by E7 “*I think whether we are remote working or not, the impact would be the same, because in both contexts it is good to have feedback between all of us, what is going on, what is the state of play, so that we can advance (...)*”.

The biggest concern about the mental health during the pandemic was how faster software developers could reach a burnout stage. This happens because people are much more socially isolated during the pandemic, because of the pandemic context, and because of having a hard time separating work from leisure, which all have a negative impact on the mental health. The burnout has an enormous negative impact on a person, which in turn negatively affects one’s productivity. This is why the access to a psychologist and therapy was an important topic, to mitigate the risks of one hitting a burnout stage and address the ongoing issues in one’s life that might end up leading to it. The promotion of mental health during the pandemic was also important to help people dealing with their mental health issues, such as meetings and presentations about mental health topics, promoting access to psychologists, among others. Despite not having many mentions, since we did not interview many Managers, we had reports of them actively paying attention to their teams’ mental health, as told by E18, “(...) *so, at the time as a manager what I did was basically be there for the team, pay attention to their mental health, be particularly attentive*”.

and make sure that they have the ideal possible conditions to work (...)". Our recommendation is for companies to invest in the mental health of employees, and encourage them to take care of their mental health, even in the pandemic. This can be done by simply encouraging them to maintain a routine, providing access to psychologists and therapy, provide meditation and mindfulness initiatives. Once again, we reinforce the importance of promoting communication, in this case to address the negative impact of isolation on the mental health, but also allow people to be attentive to early signals of burnout of others, to be more effective in mitigating mental health risks.

As for the physical health, it was equally a concern, since gyms were closed and people were restricted to their homes, there was a tendency to move and exercise less. While most of the interviewees expected their companies to at least promote physical health, this did not happen with almost half of the interviewees. In the cases that there was indeed promotion, they were done by online exercise classes, which is probably the most effective way to promote physical health. We had mentions of these online classes also being of meditation, which also helps with the Mental Health. The other type of promotion was through social events outside of lockdowns, to relax. Doing these during remote work are important to ensure that people are not sedentary and take care of their physical health.

The working hours also saw changes during the pandemic, which are mainly caused by the shared space of working and leisure during the pandemic, making one work more hours. But, it seems like the way one works also affected how the number of hours are perceived: our interviewees were making more and bigger pauses during the day, which reflects on a different schedule, but the number of working hours end up being around the same. The number of hours is not directly related to the productivity, just because software developers are potentially working more hours does not mean that they are more productive. As for the timesheets, they are more than a way to keep track of time, as they allow keeping track of one's efforts in tasks.

As referred before, the pandemic required new skills and technologies to be acquired, to be able to adapt to the pandemic. But for some people, these were already adopted, and only the way they were used changed, since now there is a much bigger focus on the synchronous communication through the tools. These tools also help that information is saved and lasts longer. An interesting follow-up research could possibly be how the requirements for the tools evolved with the pandemic, and how the pandemic changed those tools.

The development of software barely changed with the pandemic, since a lot of the processes were already done through a computer and did not require one to be in the office in person, unless for access to certain systems. Nonetheless, there were some reported changes that did not make it to the theory, such as having more autonomy when programming, or it being more rigorous with meetings. This autonomy might be a reflection of more trust on employees, as reported by managers, but further research is required to understand this phenomenon in depth.

Concerning privacy, from our interviewed population it seems like overall it was not

something that people worried much about, as they naturally felt their privacy protected, and they felt like they had control on their own privacy. Those who felt they had less privacy were mostly concerned about image sharing and the space they were in. The tools ended up mitigating the latter, by filtering away the background images and replacing it with blurred images, or fully virtual backgrounds, during video calls.

During our interviews, for those who had recently started working on a company, we did questions about their onboarding during the pandemic. While we did not have many interviewees participating in onboardings, from the ones who did and the ones that observed that the onboarding experience during the pandemic was perceived as much harder, as told by E17 *“I think so, because they do not know people (...) and when asking for help is naturally more uncomfortable, because if we were at the office we would ask the person next to us, and being remote we have to wait for the other person to respond (...) so yes we can see some difficulties, we recognise that for a new person it must be much harder to start now.”*. It would be interesting a follow-up research that deepens this topic, to understand how different parts of the onboarding were affected. We also had very few mentions on how the onboarding changed with the pandemic, and it would be interesting to see this researched further.

With respect to Quality Assurance Analysts, we were unable to interview enough people with that role to achieve any conclusion, but one consensus we found was that the quality of the software did not change. Further research is needed to understand if the testing process, to ensure the quality of software, among others, was affected by the pandemic.

As for the Managers, the ones we interviewed reported that the pandemic did not make them trust less on their teams. As for the communication with stakeholders, we were told that it did not change because it was already done online pre-pandemic, as told by E12 *“It is the same, I do not know, we were already used to having everyone remotely, in Spain and in other countries, in our case it is not too different.”* But overall, we were unable to interview a significant number of Managers, and more research would be required to understand how the role was affected by the pandemic. The same applies to the UX/UI Designers, since we only interviewed a single one and were unable to find new information.

Last but not least, most of our interviewees, despite all the challenges, actually perceived an increase in their productivity. The lack of commuting to the office had a particular importance on this increase, as it caused people to have more personal time for themselves. Overall, the profile of people who were reported to suffer the most negative impact in productivity during the pandemic were parents, due to having their children at home at that time. Since schools were closed at that time and classes were mostly online, there was not much that was possible to do to address this issue, other than colleagues understanding the context and not pressuring them. It is hard to understand if the benefits outweigh the challenges, since everyone had different contexts and different impacts. Another aspect to take into account it is the time frame where all this challenges

and benefits happened, as is very short. Some of the effects caused by challenges can have more impact in the medium or long term, since the accumulation of effects can have more or less impacts in the long term. An example of this would be the desensitisation towards COVID-19 prevention measures, changing how these impacts are perceived.

6.3 Post-pandemic

The pandemic brought many changes and required both companies and employees to adapt. But, what is expected to happen after the pandemic ends?

During our interviews, we asked if they would like to continue working remotely post-pandemic, and if they did, which model they would prefer. Almost all our interviewees answer that they would like to continue working remotely, and their preferred choice was the hybrid model. The reasoning for it is that it offers the best of both worlds: it allows one to have more flexibility and the choice on where to work, as said by E13 *“I would say hybrid, because it ends up being the more flexible version, if I prefer to be at home I stay at home, if I prefer to go to the office I go to the office, but it depends on me, not on a scale, and that is why I prefer it to rotation.”*. Hybrid remote work also facilitates access to systems and people, as explained by E6 *“I think hybrid, it totally has the best of both hypotheses, which is, if I feel like I need, or maybe even need to use systems, or having to talk with someone, having that possibility.”*, and finally, it promotes socialising and idea discussion more easily, as noted by E12 *“I wanted some hybrid, so that we can have some space for socialising and exchange ideas a bit more easily(...)”*. As such, the hybrid model appears as a solution to the social isolation problem that existed during the pandemic, as it gives one the opportunity to socialise with colleagues, while keeping the benefits of remote working, such as more personal time and sleep, and better sleep and well-being. One of the CEOs we interviewed confirmed that in his company, when asked the employees if they would like to go back to the office full-time, the majority of them said that they were not interested in it.

During our interviews, we asked if the interviewee thought there was a conflict of interest in the future of the remote work post-pandemic, from which the majority of the answers mentioned that there indeed was a conflict, especially because of the lack of trust on employees when working remotely. One of the reasons given for this is lack of trust, because there is some doubt from the part of the employers if the employees are working, as mentioned by E11 *“I think so, it is the conflict that it existed before, which is always that doubt, mainly in certain companies, that if the person is at home then (s)he is not working, and that maintains that mistrust.”*. This relates to some mentions we saw of people who felt like their work was as not as visible due to working remotely. Another reason for this conflict is the interest from employers to abuse employees by using remote work, as told by E10 *“Yes [there is conflict], it is not my case, but there are a lot of companies that want remote work to stay to use and abuse their employees (...)”*. On the other hand, those who think there is not a conflict are also the ones whose company trusts on them, as long as the work is delivered, as explained by E6 *“(...) I feel like there is some trust on the employees,*

they trust that the employees are in fact adhering to the working schedule and doing their work, and you can see that they are, because the work is delivered (...)”.

About the career progression and stability in the post-pandemic for those who expect to work remotely, the majority of the interviewees think that working from home does not affect at all both stability or progression of their career, as long as developers keep doing their work and keep having objectives, as said by E13 *“I do not think so, I believe that if people keep doing their work, with their objectives in mind, their ambitions in mind, we are all in the same model, so no one will be left out because of it, it will not stop.”*, and keep having contact with colleagues, as explained by E15 *“I do not see it like that, in the end as long as all is well coordinated and there is always contact with management and colleagues, I do not see that.”*. We also had mentions of software developers being really sought after in the industry, as said by E11 *“(…) but I think that the type of jobs where people have a fixed contract, permanent, and which is actually how the IT area actually is, where there is a lot of demand but little supply, for the demand that exists I do not think anyone will really suffer from it (...)*”.

About the interest of working in a global software development, nearshore or offshore panorama, about half of our interviewees showed interest in it, depending on the conditions of the work, as told by E4 *“I am of the opinion that that is always a matter of habit, I think that would be a possible option yes, but also depending on the conditions that are adjacent to this kind of work.”*. As for the interest on doing regular travels for work, the majority of the interviewees did not like the concept, with the reason that it affects one’s personal life too much, as is the case for E11 who has children, *“No, I do not want to travel because of my children.”*.

Regarding the equipment for the post-pandemic, we asked our interviewees if they would be interested in buying second-hand equipment from their company, with discount, either because the company adopted total remote work, decided to reduce their office space, or just acquire new equipment. We found that there was a lot of interest on buying discounted second-hand office equipment, because despite being second-hand, they could be in good state, as stated by E7 *“If they sold something that I had the necessity to buy, I do not see why not, although it is second-hand, I do not see the reason to discard.”*. There are two types of office equipment that are sought after, with the first being office furniture, such as chairs and desks, as noted by E7 *“For now, maybe only a desk or something among those lines, that’s what occurs to me, a desk.”* and E18 *“The chair, this office chair is really good, so if I could buy her I would certainly want to (...)*” [18], and electronic equipment, such as monitors, like E16 said *“For example, the monitor that I snatched from the office and that is currently at my home and is not mine, but if I could...”*.

An important topic that was mentioned a lot was regulations and costs for the post-pandemic. Regulations about costs expenses were the most talked about, with everyone (excluding CEOs) saying that they would like their company to help them with monetary funding for electricity, gas or internet expenses in the post-pandemic. As observed by E0, its electricity usage increased due to being fully remote, *“Actually this is something I did*

not think about, but I really end up using more electricity due to being at home full time, that otherwise I would not use if I was at the company, so I think it makes sense to be there any kind of monetary help, like an allowance that could take that into consideration.”. But, inside those who would like some monetary help with expenses, there are two perspectives, with the first one being that it should be something voluntary for the companies and should not be mandatory, as told by E5 *“Yes, I think they could do it voluntarily, be it should not be mandatory (...)”*, or only help with electricity when the increase of expenses is proved, as explained by E3 *“(...) on electricity only if it was proved that the increase that the person is having, the electricity expenses are superior to the expenses that existed due to travels, if it was in person (...)”*. As for the time of this writing, the Portuguese Parliament has approved a new bill regarding the remote work, where it mentions that it is the employers’ responsibility to cover its employees’ expenses, when the increase due to remote working is proven, meeting the expectations of our interviewees. [47, 48]

Another important type of regulation that was mentioned was the creation of regulations to guarantee that an employee, while remote working, has all the necessary conditions to work. These can either be related to equipment, as said by E11 *“(...) and also makes sense that all the necessary equipment is provided, whether it is a chair, whether it is IT equipment, so that work is done remotely.”*, or even beyond the equipment, all that can impact an employee, as told by E17 *“(...) guarantee that the companies give the necessary tools for people to work, not only in technological terms having the computer and the screen, but everything that impacts when one person is working (...)”*. This seems to reflect on the necessity of acquiring equipment during the pandemic that was necessary for remote work, and in some cases not having a space ready. The previous mentioned bill also includes that it is the employees’ responsibility to provide all the required equipment for one to remote work, and that they have to cover any expenses also related to that. [47, 48]

Last but not least of the regulations for the post-pandemic, it is the regulation of the working hours. As we saw during the pandemic, some people ended up working more hours due to space-related issues. As such, something that our interviewees would like to see post-pandemic is a regulation that protects the employees’ working hours from being abused, and the right to being offline, as said by E10 *“(...) and there should be regulations to not allow employers to abuse employees in terms of working hours at home (...)”*. The bill about remote work mentioned before also contains the right of disconnecting, which does not allow employers to contact employees past their working schedule, which is a step towards these expectations. [47, 48]

The most expected change for the Development post-pandemic is it to continue focusing on the asynchronous, as there will exist more asynchronous communication among colleagues, as told by E16 *“The focus on the asynchronous and on the offline, I think it is something to maintain, we will contract even more people from other country, we will be contracted more by other people from other countries, it makes sense to continue having an offline-focused mindset and people being able to work offline (...)”* and semi-asynchronous, to maintain collaboration when working simultaneously, as told by E6 *“(...) I think the*

more important there is to continue to use the collaboration software, and use it correctly to allow more easily multiple people continue working remotely, and to not exist neither problems neither annoyances (...)”.

Last, but not least, for the post-pandemic expectations, the majority of the interviewees would like online social events to continue post pandemic, for the exact same motives that they were a success during the pandemic: to maintain social contact, as told by E3 *“Yes, I think they still are important, to keep that sense of..., it is not team, it is more to have that social contact and keep it (...)*”, and because it benefits well-being and, in consequence, one’s work, as told by E4 *“Yes, I think that it adds value, not only for the employee’s well-being, but also for the role that they perform, because one thing ends up influencing the other.”*

During this chapter, we summarised and discussed the different aspects of the theory, such as the benefits and challenges of remote working, the issues with the remote work during the pandemic, how the different categories relate to each other. We also presented some aspects of the pre-pandemic, and the multiple expectations for the post-pandemic.

RELATED WORKS

This chapter reports research on the impact of the COVID-19 pandemic on software development. The analysis of the related work will be done systematically to extract information on **Methodologies, Population, Research Questions, Interviews and Surveys, Analysis and Results**. [Table 7.1 – Summary and comparison of the related works analysed](#) summarises all the following related works into a single table.

7.1 Methodologies

A research methodology describes what type of data will be collected and how it will be collected, what topic will be addressed and how, and how the data will be analysed to derive results from it.

Bao et al. [3] uses development activities recorded for 139 days of 138 developers, including both working in office and working from home during the pandemic, to find the different impacts of the COVID-19 pandemic based on different metrics. They compare developers and projects with respect to productivity, using appropriate statistical tests.

Bezerra et al. [6] analysed the multiple organisational and human factors that influence Brazilian software development teams during COVID-19. They conducted an online survey to gather practitioner's perceptions and used some **Grounded-Theory** inspired steps to code the survey results and find relationships among those codes.

Butler and Jaffe [9, 10] conducted an **in-situ** anonymous study with software engineer volunteers. A daily survey was conducted to gather reflections. After having collected the data, a thematic analysis was performed. This allowed to identify challenges, gratitudes, and how regular reflection affects software engineers' satisfaction and well-being.

Camara et al. [12] used **action research**, an empirical methodology where researchers try to understand real-world problems while studying the experience of solving those problems. They conducted action research on a startup to address the uncertainties caused by the COVID-19 pandemic. They identified existing problems and uncertainties, and planned actions to address them. Some of these actions were the establishment of

collaboration guides, control of source code and more were applied to the agile development cycle. After the conclusion of all actions, an evaluation of how the actions affected the uncertainties was done.

Ford et al. [19]’s methodology uses a set of online surveys to understand how software developers were affected by the pandemic. An initial survey was sent to software developers of a single location, to understand their experiences during the pandemic. The results of this survey were analysed using **open coding** and the second survey was based on it, to identify the frequency of benefits and challenges. The data of this second survey was analysed using the least absolute shrinkage and selection operator (Lasso) to select the most important variables.

Ganguly et al. [22]’s methodology addresses the impact of the COVID-19 pandemic on the productivity of software developers, and consists of identifying the problem and using a survey to collect data, to analyse the patterns and relationships of factors. There were 5 steps in this methodology, with the first being the construction of the questionnaire. The second was conducting a pilot survey, to evaluate and refine the questionnaire, incorporating feedback. The third was the conduction of the survey among IT professionals from Bangladesh. The fourth was pre-processing of responses. The final was the descriptive analysis of the data, with resort to data visualisation, to gather conclusions.

Mendonça et al. [34] conducted two studies to understand the impact caused by the transition to working from home. In the first study they **mined a software repository** to observe the activities of a development team, to identify challenges, benefits and how work practices changed. In the second study, they **interviewed** stakeholders (including developers, to understand their motivations, expectations and the exchange of experiences. Two pilot interviews were conducted, to review the scripts and improve them. In total ten interviews were carried, and shortly after they were transcribed to allow to gather relevant information and insights.

Oliveira et al. [40] conducted a **survey** to understand the impacts of COVID-19 on the perceived productivity. The population for the survey was software developers, gathered from social media, and the survey was designed with exploratory research in mind. An analysis of the gathered data through **data visualisation** allowed to draw conclusions.

Ralph et al. [45] also used a survey-based methodology to understand how COVID-19 affects software developers and how companies can help them. A **survey** in multiple languages was conducted, with the target population being software developers from all around the world, found from social media and news websites. A questionnaire of the survey was designed, and a pilot survey conducted for feedback. The data resulting from the surveys was then cleaned and analysed, and models that try to support the hypotheses were created, allowing to refuse or confirm them.

Russo et al. [51] addresses predictors for developer productivity and well-being through a two-wave **longitudinal study**. They conducted two surveys. The first is used to identify the variables that explain unique variance in productivity and well-being, while the second is used to measure them. The population for these surveys were software engineers

from all around the world, gathered through the Prolific platform¹. There are three analyses, one for each wave and one intermediary. The first analysis makes use of regression analysis, the intermediary of correlation, and the second of statistical estimators.

Most of these research efforts used online surveys. These survey-based studies usually design the survey around their research questions and conduct a pilot survey to received feedback, and improve their instrument as needed. The survey is then published, and its data is analysed using statistical methods, which in turn allow to draw conclusions. In terms of data collection, it seems that most of the presented researches make use of surveys for it, but it would have been interesting to see other techniques being used. Out of all these surveys, the action research, interviews and software mining have the most unique approach and offer a different perspective.

7.2 Population

Given how most data in these related work are collected from individuals, the human factors play a huge role on their answers. Since different political and social-economic contexts can heavily affect one's life and the companies, it is important to look at details of the population of each work. We aggregate populations by continent, where the political and social-economic contexts tend to be more similar, to conduct our demographic analysis. Some studies might have data from multiple continents or do not disclose participants origin. We will address those studies at the end of this section.

7.2.1 North America

Starting with North America, the only research whose population is specific to this continent is Ford et al. [19]. Two different surveys were sent at different times to different populations, with the first survey being sent to about 5,000 full-time employees from King County, Washington, US, that are part of a software team, with 70% software developers and 30% program managers. This survey had a response rate of 27%, claimed to be on par with many other software engineering surveys. The second survey was sent to 9,000 unique engineers from all the US (except King County for no overlaps), included data scientists, developers and program managers, but the amount of each one was not disclosed. The response rate was 25%. Unfortunately, the second survey does not disclose the distribution of the survey answers per role, as it would have helped to compare with the first survey, and since each state reacted differently to the start of the pandemic, the distribution of answers per state would have been useful.

7.2.2 South America

All South America studies come from Brazil. This might be because it is one of the most affected countries by COVID-19, and because they have a very active experimental

¹<https://www.prolific.co/>

engineering software community. Camara et al. [12] focuses on a single Brazilian software development startup. The study was conducted on a single team, composed by one scrum master, one product owner, one technical leader and six developers. Most of the team before pandemic used to work on their co-located office, changing to remote work with the start of the pandemic.

Mendonça et al. [34] also focused on a single team of 20 developers. They interviewed five developers, two stakeholders, one UX/UI designer and one software architect. All the developers and the UX/UI designer had less than five years of experience. The scrum master and software architect had five or more years of experience. The developers were the only ones without remote work experience. Most team members except the Software Architect and a developer had an exclusive space for work environment. Three team members share their house with three or more people, while the others share at maximum with another person.

When comparing the two previous researches, Mendonça et al.'s provides more information about the team members. Although stakeholders play an important role in the research, not much information about them is given, and it would be interesting to actually know some information even if they do not impact directly on the productivity. Some suggestions would be for how long they have accompanied the project, how was their availability previously, how often did the team meet with them, what was their involvement and so on.

In Bezerra et al.'s work [6], the population was invited both from social media (Facebook, Instagram, mailing lists, among others) and through direct invitations to software development companies. In total, there were 58 participants from all over Brazil, with a distribution of 53% in the Northeast region, 19% in the Southeast region, 7% for both South and Central West regions, and 14% for the North region. It was found that 91.4% of the participants work in small teams, up to 20 members. The participant list is composed by UX/UI designers, developers, requirement analysts, project managers and testers, but the percentage of each one was not disclosed. Furthermore, 55,2% of the participants have less than five years of work experience, and 44,8% have more than five. Regarding where each individual worked before the pandemic, 71% worked in person, 24% worked in both in person and at home, and 5% already worked full-time from home.

Last but not least of the Brazilian researches is Oliveira et al.'s work [40]. The population was gathered from social media, which resulted in a sample of 413 answers of an online survey conducted between 7th April 2020 and 26th May 2020. According to it, 93,95% of the ages fall in between 18 and 59 years, with most occurrence in the range of 18 to 45 years. About 75% of these 413 participants are software developers, followed by product owners which are equivalent to 9,2%, 6,54% correspond to data scientists, 3,15% testers and 6% to others. Regarding the experience, those with two years or less of experience amount to 13,56%, while those between two and five years correspond to 22,76%, between 5 and 10 years 18,16%, and finally, those with more than 10 years of experience

correspond to almost half of the participants, 45,52%. This research also presents percentages regarding the type of contract of the participants, with 72,40% being full-time, 8,23% were owners of a company and 8% freelancers, while other types of contract corresponded to 11,38%. About the size of the companies, most of the participants belonged to a company with over 100 employees (62,95%), followed by medium companies with between 10 a 50 employees, corresponding to 18,40%, while participants working on medium to big companies with 50 to 100 employees are only 9,44%, and finally, only 9,20% of the participants work in startups with up to 10 employees. The online survey also asked how fast the their companies moved into fully remote work since the start of this survey, and the majority started after four weeks or more (67,80%), followed by the ones that moved after three weeks with 28,57%, and finally, two weeks with 3,63%. Information about the number of hours and productivity of respondents are also given, as well as communication tools, development processes (where Scrum overwhelmingly is the most used) and remote work.

Looking at these two researches, Bezerra et al. Oliveira et al. ask several relevant questions, and thus, their research has a very complete and diverse population. Bezerra et al. [6] take a very similar approach but when compared, it is more incomplete, given that a lot of information about the participants is missing.

7.2.3 Asia

Moving forward to Asia, two researches were found, one conducted by one of the biggest companies of China, Baidu, and the other on Bangladesh.

The first research is by Bao et al. [3]. Unlike the other previous researches, this one is a quantitative research that does not rely on interviews and surveys. As such, not much information about the population is disclosed. The daily activities of 139 developers of Baidu were gathered during a period of 138 working days, as well as the number of commits, number of inserted lines, among others. While there is not much information, the research offers a different perspective on what kind of data can be gathered from a population through methods other than surveys and interviews.

Ganguly et al.'s research [22] focuses on IT professionals from Bangladesh. A questionnaire was circulated among IT professionals throughout a month. On total, there were 1062 valid respondents from 29 of the 64 districts of Bangladesh. No more information is given about the population. Compared to some previous populations, it might have some more participants, but the information about the population is very incomplete, since the role of an IT professional, the amount of experience on IT, if it previously had experience with remote work and much more play a huge role when analysing the productivity.

7.2.4 Other Regions

Last, but not least, are the researches whose population are distributed between different countries. Compared to the previous researches, these allow to have a more general idea

of how the pandemic has affected software development despite the social-cultural and political context.

The first of these is the Butler and Jaffe's analysis of challenges and gratitudes [9], and they did an *in-situ* study with volunteers. An email was sent to about 2000 Microsoft engineers over the world explaining the research and asking for volunteers, which resulted in 435 participants, with a response rate of about 22%, which seems on par with the rest of the researches. The participants belonged to the following locations: United States 80%, Asia 14% (India, Israel and China), 3% from Dublin, 3% others. The gender distribution was predominantly Male, with one third being Female, and 4% others. Last but not least, 63% of the respondents were software engineers, 17% project managers, 6% each for engineering managers, designers and others, and 2% for administrators.

The next one is Ralph et al.'s research [45], where the target population are software developers from anywhere in the world who had to switch from working in an office to work from home. There were 2225 respondents, most of which are overwhelmingly male (81%) and full-time employees (94%), with a median age of 30 to 34 years. Half of the respondents live with other adults, and 27% live with one or more children, of which 13% indicate their children has a disability. There are multiple roles among the population, but software developer has an 80% prevalence. More than half (58%) did not have previous experience in working from home, and of those who did, the median experience is 1.3 years. The top three countries with the most answers were Germany, Russia and Brazil. Very few participants contracted COVID-19 or live with someone who did, and 13% were currently or previously quarantined. Most of the population had a degree (undergraduate or masters), and the size of the companies are mostly found between 10 and 10000 people.

Ralph et al.'s research is the only survey where a European country is the most predominant, but also has the most diverse sample of countries. It offers some very interesting statistics about the population that the others populations do not contain, such as if someone's child has a disability or if the person had contact with COVID-19 or not. When looking at Butler and Jaffe's population, it feels more like a United States focused research since it does not have that much variety, but it has a more disperse distribution of the roles.

Russo et al.'s population from Prolific, a data collection platform, which allows to recruit target participants (software engineers) who are interested. 483 candidates were invited, of which 305 were software engineers, and of the 305, those who were from countries with mixed or unclear policies were excluded. On the first wave, 192 participants completed the survey, and on the second wave, there were 184 participants, resulting in a 96% participation. The mean age of the participants were 36.65 years, with a big gender majority of male (80%). The countries with more participants were the [United Kingdom \(UK\)](#) (33%), the [United States of America \(USA\)](#) (27%), Portugal (10%) and 30% of other European countries. The majority of the respondents (84%) live with other people, and 81% work for private companies.

Overall, most of these populations seem to cover a variety of roles, ages and experiences. In this case, it is extremely important to know if the population had previous experience in working from home, since it can heavily affect one's experience while working from home. There were some very interesting information about some populations, such as how fast companies changed from office work to work from home, if participant's children had any disability, if they had contact with COVID-19, among others. It would have been interesting if more researches included UX/UI designers, requirement analysts and more.

7.3 Research Questions

As referred before, research questions are one of the most important aspects of researches, since the research itself revolves around them, and they are the questions that the authors are trying to answer. While each question tends to be unique from research to research, they might address similar topics, and as such, they can be grouped into categories. The categories for research questions that were found when analysing these related works were **Work Environment, Technology, Company, Projects and the Developers' Productivity and Well-being**.

Starting with those related to the **work environment**, this seems to be the one of the topics that's shared among most all the researches. Bao et al. [3], Bezerra et al. [6], Butler and Jaffe [9], Ford et al. [19], Mendonça et al. [34] in their respective researches investigate whether the sudden change of working environment during the COVID-19 pandemic can affect one's productivity, and if so, what kind of differences, benefits and challenges can arise from it. These very same researches have research questions regarding what benefits (or gratitude) and challenges were found during work from home. Bao et al. found that work from home has different impacts on the productivity depending on the metric, and that the productivity of most developers stayed similar to when working in office. Ford et al. and Butler and Jaffe reported similar benefits (or gratitudes), with them being less commute time, more schedule flexibility, fewer distractions, among others. Bezerra et al. reported that the challenges of working from home are related to interruptions, adaptation and emotional well-being, being the categories that mostly impact productivity when working from home, while Butler and Jaffe found that connectivity, too many meetings and overworking were major challenges. Ford et al. found similar results to the previous two, with the addition of lack of motivation and difficulty in communicating with colleagues. Mendonça et al. found that the number of meetings with the stakeholders was reduced, and thus, procedures to validate the product also became a challenge.

Another topic that was found was regarding how different **technologies and skills** can affect the productivity of software developer's when working from home, whether they are communication tools or technologies used in software projects. Bezerra et al.'s

research [6] addresses how technical experience and individual skills can impact the productivity of a software developer. One of Oliveira et al.'s [40] research questions, is if the number of adopted technologies affected the productivity. One of Bao et al.'s [3] research questions addresses how the productivity is influenced by different programming languages. Bezerra et al. found that having experience and individual skills does influence the productivity positively, as it helps to perform better at tasks. Oliveira et al. found that developers who had an increase in productivity had to adopt and learn more tools than those who had a decrease. Bao et al. concluded that programming languages can impact productivity, and in their research, Java projects have a negative impact, while C++ had a positive impact.

Moving forward, the research questions about **companies** are important to know how the companies dealt with the COVID-19 pandemic, and if they tried to mitigate some of the problems that arose with it. Bezerra et al.'s research [6] question regarding this topic is how companies helped their employees to ensure good productivity, while the whole research by Camara et al. [12] tries to answer the research question on how a software development Startups approached uncertainties. Ford et al. [19] take a different approach on the research questions, where instead of looking into what measures the companies took, the question focuses on what recommendations should be made to companies. Bezerra et al. found that a considerable number of participants did not have help from their companies, but those who did, received a financial or material assistance. The most asked improvement on remote work was work environment. Camara et al. found that promoting socialization events, establishing socialization guidelines, knowledge sharing, impose code standards and more help to manage and reduce the uncertainties. Ford et al. recommend that companies provide better hardware, internet, stipend, software, guidelines and support.

Since the COVID-19 pandemic inevitably affected ongoing **projects** and future projects, it is important to know how projects can affect one's productivity, and how projects adapted to changes. Bao et al. [3] try to deepen more this topic, by having three research questions regarding how difference project types, ages and sizes can affect developer productivity when working from home. Oliveira et al. [40] takes a more specific approach by asking if there was a change in the development process to formalize artefacts in order to reduce the communication, and Mendonça et al. [34] looks further into the perceptions of developers and stakeholders on COVID-19 pandemic and the need to follow a work from home configuration to follow the project. Bao et al. found that projects of type APP can influence both positively and negatively the productivity, while the types SDK and SERVER impact negatively most of the time. It was also found that project age does impact productivity, with older ones more positively, because newer projects tend to have more tasks associated. As for project sizes, smaller projects tend to impact positively when compared to large projects. Oliveira et al. discloses that those who previously had adopted an agile methodology had very few changes, but overall, there was an increase in the number of meetings and in the informal communication. Mendonça et al. reports

that stakeholders had less availability, which had an impact on requirement elicitation tasks and establishing new partnerships.

Last but not least are the two most important correlated topics, the **developers' productivity and well-being**. It is extremely important to know how the productivity was affected, but also if their well-being was impacted and in turn impacted their productivity. Ralph et al. [45]'s whole research revolves about the research question on how working from home is affecting software developer's well-being and productivity, while all the other authors of previously mentioned papers share similar research questions to this one. Russo et al. [51] also takes a more focused approach on a single question, trying to answer the research question on what are the relevant predictors of well-being and productivity. Ford et al. [19] and Oliveira et al. [40] take a more widespread approach by asking what were the differences in productivity since working from home. Ralph et al.'s answer was that productivity and well-being were indeed impacted, in this case, negatively. Ford et al. and Oliveira et al. found the similar answers to whether productivity had been impacted, by reporting that the pandemic caused more initially people to report lower productivity, but later, higher productivity was reported. The predictors found by Russo et al.'s predictors were competence and communication for productivity, and for well-being autonomy, stress, extraversion and more.

Overall, there is a broad range of research questions, but a lot of them feel very similar, with only a few standing out. The impact of the pandemic is something that already seem very substantiated and with a lot of focus on a single individual, and since software developers tend to work in teams, it would be very interesting to study how was the impact on whole teams. Adjacent teams to software development teams were also somehow impacted by COVID-19, and discovering how that translates into the software teams would be very interesting.

7.4 Interviews and Surveys

To answer the research questions, interviews and surveys had to be conducted within companies, with software teams or individual software developers. The questions contained on them are important since they are the source of data and allow to construct the answers to the research questions, and as such, they are usually related to them.

Surveys are a method that seek to gather information from a sample of a population, and with it, provide data and insights while also generalising them to a larger population [63]. They can be conducted in many forms, but more commonly they make use of questionnaires. In this context, the surveys are used to gather data about not only from software developers, but also project managers and designers during the COVID-19 pandemic.

Starting with Bezerra et al.'s [6] survey, it was built with the goal to analyse human and organisational factors influence software developers during the COVID-19 pandemic in Brazil. For this, the survey was divided into several sections according to human and

organisational factors that the authors found in literature. Each section (except the one about profile) contains questions regarding a single research question. The first questions are about the profile of the participant, and are concerned about their region, their team, their role, their experience and what modality of work they exercised before the pandemic (full-time attendance, half office half home or full-time home). The first section is about work environment and contains questions about previous remote work experience, if they had a dedicated space and if the presence of family in their household impacted them somehow. The second section is about experience and skills, and team members' skills and experience contribute to a better progress and influence the progress. The third section is about the organisation and collaboration, by referring to topics such as stakeholder participation, rate turnover, changes in working hours, among a few more. The fourth section was regarding remote communication, and asks about how it is realised, with which tools and the positive and negative impacts of them in productivity. The fifth section is about motivation, emotional and health, and tries to understand how motivated software developers were, how they felt and what they did to keep their health up to date. The sixth is about the helps from companies, and if they provided any help, what kind of help and how can they help improving the performance. Finally, the seventh section is about how software developers perceive their own productivity, and if they saw any impacts from remote work.

Butler and Jaffe [9]'s approach to a survey is different, since it requires the participants to answer daily during 10 weeks, acting like a journal, where they can register their gratitudes and challenges. After the 10 weeks, another survey would be sent, where participants can inform on their experience. During the 10 weeks, the survey would be composed of four short required questions and one optional text section. The optional text section was used to gather time-sensitive information, or details about previous questions. The example provided shows one question regarding how much the respondent was satisfied with work from home, one about what was the hardest part of the day, other similar question but about what the participant was grateful about, and a question to rate the collaboration on documents.

All the surveys and questions of Ford et al. [19] are provided in an appendix [20]. The first survey has a total of 58 questions, and is focused on uncovering the main benefits and challenges that software developers faced during work from home. The survey is divided into two slightly different surveys, one for those who were working from home and those who were not, and is mostly composed by open answers. The first 10 questions are about consent and the profile of the participant, and also if it worked previously from home. The following 12 questions are about the experience and challenges of work from home, work environment, interruptions and distractions, the changes in productivity and communication, among others. There are 12 questions about meetings prior to work from home, and they are essentially about the number of people that were present, how many participated remotely, and about commuting to work. The second survey is used to uncover developer's self reported changes in productivity with working from home, and

how the benefits and challenges correlate to those changes. This survey starts by differing from the first by initially asking if the participant has children that attend school, and if so, how difficult was the child care during the pandemic. Some questions are mostly closed answer and are about how the productivity has changed, how much work it gets done in an hour, what are the benefits of working from home and how important they are, what are the challenges and how impactful they are, if the team culture changed, what improvements could be made to working from home, and more.

Ganguly et al. [22]'s survey was composed by 47 questions, and asked participants about their personal and work life, to understand how they affect the productivity when working from home. Based on existing research, the authors chose 24 factors related to productivity and designed questions and answers to understand how each factor changed when working from home. The Likert scale, a scale widely used for scaling responses, was used on the answers. One of the example questions provided is "*During work from home, I get useful feedback about job performance*", which, in some way, requires participants to perform an introspection and reply according to their perceived productivity.

Oliveira et al. [40] opted for an exploratory survey, with the goal to find out the perceptions to a certain degree related to the impacts of COVID-19 on productivity. The data set and survey are fully provided in an appendix [39]. The survey was designed to reduce the threats related to fatigue or motivation when answering, and as such, it was planned that it would not last longer than 10 minutes, and to mitigate the threat of redundancy, the language used was simple and easy to understand. It contains questions based on the Likert scale, scales in intervals, nominal and open. The structure of the survey is similar to Ford et al.'s survey, with the initial section being about the profile of the participant (role, years of experience, among others), and the second about working from home during the pandemic, containing questions about if the number of working hours changed, how productivity was impacted and what the reasons for it, what communication tools are used, if development processes changed and how, if the company provided help, among others.

Ralph et al.'s [45] survey was translated to 17 languages and was totally anonymous. The survey made use of a filter question to exclude those who did not fulfil the criteria (people who had not switch to work from home). The questions were organised depending on their question type and on their scale, and a multi-item scale had their answers randomly ordered to mitigate primacy and recency. The same did not happen to the various sections because it is important to understand which one is before the obligatory working from home and which is after. All versions of the survey are available in the appendix [60], along with the data set. The survey contains in total 37 questions, some of which are about the profile of the participant and 5 sections. The questions about the profile contains the usual questions (age, experience, role, and more), but also asks about the COVID-19 status and how much the participant has left their home. The first of the sections is about resiliency, which is related to the reaction to bioevents, such as a pandemic, and tries to assess how the respondent feels about the COVID-19 pandemic.

The next section is about disaster preparedness and ergonomics, and it is about how the participant prepared himself for the pandemic, and if the workspace is acceptable and has good ergonomics. The third section is a single question about several statements related to the extent of which the company supported the participant. The fourth section is about the emotional well-being during working from home, and it is about how the participant felt overall, to non-COVID-19 related matters. The final section is about productivity and how it was affected during the pandemic, and by what. It would have made sense if the questions related to profile of the participant were together, instead of divided in two parts, one in the start of the survey and one in the end. In one of the questions, the participant is asked to react to multiple statements (over 20), and it would have made sense for it to be either divided into multiple questions, put an open text question next to it to give details or have an option "*Does not apply*", since some of those statements might not apply to some participants.

Russo et al. [51] survey uses a longitudinal design and as such it is composed of two waves with a difference of two weeks between them. The first survey is composed of more than 53 questions and has a maximum duration of 20 minutes, while the second wave has 18 questions (excluding consent and demographics) and has a maximum duration of supposedly 5 minutes. A document of both waves and their data are provided by the authors [52]. The first survey is divided in three blocks with no apparent logic, and as such, the order of questions might be randomised. The questions are about similar topics of previously mentioned surveys, covering emotional well-being (stress, anxiety and more), productivity, work environment, communication and more. There are some interesting questions that were not found in the previous surveys that tackle a few more topics and provide new insights about the pandemic. Some of these questions are, for example, the participant's belief regarding the COVID-19 pandemic (e.g. if it is a bioweapon), how (s)he complies with COVID-19 prevention behaviours (e.g. washing hands thoroughly), how (s)he copes with stress, if s(he) volunteers for a community, and much more. In terms of complexity, this survey seems to be overly complex, since it is composed by a lot of complex and long questions, some long answers and also questions with a lot of statements (some with more than thirty). While this might be with the intention to maximise the number of initial data acquired, it makes a lot harder for participants to maintain their motivation and concentration. The questions of the second survey are a subset of the first survey, but in this case they are much more simplified and accessible. This second survey serves to see how participant's answers changed after the initial wave.

Overall, most of these surveys tend to have the more or less the same structure, with questions being simple and straight to the point, and the answers usually in Likert, nominal or interval scales. At least one question is open so that participants in the surveys can give more details if needed. Almost all surveys ask about the profile of the participant, but some contain very relevant questions that give more insight, for example if the participant has children. Asking if the participant has disabilities, or is a parent of a child with disabilities seems like a fundamental question that was not covered in all surveys,

since these tend to be more affected in productivity. As for the tools, Ralph et al. advise against using Google Forms to conduct scientific surveys, because it is blocked in some countries, it does not record partial responses and bounce rates, among others. Instead, it suggests [Qualtrics](#) (also used by Russo et al. [51]) or [LimeSurvey](#). Very long surveys and complex questions (or answers) should be avoided, since they can cause fatigue or lower the motivation of participants. In these cases, there should be a special attention to those who have disabilities or disorders (for example, dyslexia), since it makes the surveys a lot harder for them. One of the downsides of surveys is that there might not be an opportunity to clarify some answers or allow other equally relevant matters that are not addressed to be deepened.

Moving to interviews, they are a conversation between an interviewer, who coordinates the conversation and asks questions, and the interviewee, who responds, with the intention to gather information.

Mendonça et al. [34] carried a semi-structured interview, where there are predetermined questions, but the interviewee can give any answer. It has the benefit of flexibility, since it allows the interviewer to ask additional questions that originally were not considered. The interviews were divided into three phases, with the first one being related to the interviewees' experience in software development and with the technologies used in the project. The second stage was about how many hours the interviewees' expected on the beginning of the project and how many hours they dedicated on average to it, as well as the benefits and challenges of working remotely. The third and final stage was how they dealt with the challenges of working from home and how was their adaptation to working from home. The interviewees were allowed to stop whenever they wanted, and in average the duration of the interviews was 23 minutes.

There's a big lack of researches that resort to interviews to gather data, and the one who uses interviews does not tackle many topics, or at least does not give much information about what other kind of questions came up that initially were not planned.

7.5 Analysis

After gathering all the necessary data, most papers have to analyse their data to draw conclusions and insights from it. Depending on the type of data collected, different methods can be used to analyse the data.

Bao et al. [3] analysis is divided into several parts according to the research questions. In the initial research question, they group the several records of their data set and compute aggregate values such as mean, median, sum, max and min for each numeric metric for each day, which allows knowing the distribution of developer's productivity. For each aggregation function of a metric, they are divided into two groups, one for developers who are working from home, and other for developers who were working in the office. Then, the Wilcoxon rank-sum test, a non-parametric test to compare the outcome between two independent groups, is applied to investigate if the difference between the

two groups is statistically significant in terms of each numeric metric. Cliff's Delta effect size, another non-parametric measurement to estimate the effect size (differences) when comparing two groups of observations, is also used to quantify the difference between those working at home and those who were not. This approach would end up being used similarly in all the research questions analysis.

Bezerra et al. [6] analysis makes use of two different types of data, one qualitative and another quantitative, and as such, two different methods are used for analysis. For the quantitative analysis, descriptive statistics, which describe basic features of data, were used to characterize participant's data. Some procedures of Grounded Theory were used to analyse qualitative data, in particular, two phases of coding. These phases were open coding, where concepts are generated from data through interrogation of it, and axial coding, which consists of specifying the dimensions of categories, associate subcategories to categories and delineate the relationships among them [15, 1].

Butler and Jaffe [9] performed a thematic analysis on their qualitative data, which is a method used for identifying, analysing, organizing, describing and reporting themes within a data set [38]. In this case, it was used to analyse the data, find themes, commonalities and key concepts. Open coding was used with two questions in mind, "*What was the hardest part of your WFH day?*" and "*What are you grateful for in your WFH day?*" to code 200 responses, through multiple iterations, resulting in 19 categories.

It would have been interesting if Bezerra et al. [6] actually made a full use of Grounded Theory and came up with a theory, since using a few steps of Grounded Theory does not mean it was fully used, and in case of Butler and Jaffe, there seems to be a lack of steps after the coding, because it is not described what codes resulted from the open coding, what themes were found and how codes related to the themes.

The research by Camara et al. [12] does not specify any type of analysis method, and instead analyses how each action affected a development cycle.

Ford et al. [19] analyse the two surveys in different ways, where in the first one is a thematic qualitative analysis, which makes use of an open coding approach on open-ended questions, with multiple rounds of iterating and refining. The codes were based on three of the four research questions, the ones concerning about positive/negative aspects of working from home and possible improvements. The resulting 32 codes were organized into one of the following themes (1) beyond work, (2) collaboration, (3) communication, (4) well-being, (5) work, (6) and work environment. A count of the codes was made to show the frequency on all of the sample, with family, children and pets being the highest one of the beyond work theme, social connections for collaboration, channels for communication, commute for well-being, interruptions and distractions for work, and environment for work environment. On the second survey, we can find a statistical quantitative analysis, where descriptive statistics are presented about benefits and challenges. Wilcoxon Mann Whitney (same as Wilcoxon rank-sum test previously mentioned) and Fisher Exact Value tests were used to check for statistically significant differences, and Benjamini-Hochberg procedure (procedure to reduce false discovery rate) was used

to adjust p-values. To identify the benefits and challenges that are strongly correlated to productivity, the least absolute shrinkage and selection operator (Lasso, a regression method that selects the most important variables) was used. In this case, a variable is only selected if it explains enough of the variation in the dependent variable. After Lasso, a standard linear regression is used with the selected variables, to get coefficients that are not shrunk.

Both of the analyses on the survey feel very complete and complement each other, while also offering different perspectives on the matter.

Ganguly et al. [22] does not give much information about the analysis, but a descriptive analysis was conducted on each of the factors gathered, to have a general idea of the data and discover patterns and relationships among all the factors.

The only analysis that Mendonça et al. [34] contain is of interviews, which were transcribed with the aim to verify if all relevant information to understand the interviewees' perception.

Oliveira et al. [40] analysis is not specified. The data is described in distributions per questions. There are five graphics that relate variables (questions) to provide some additional information (e.g. companies size and role distribution).

Ralph et al. [45] did multiple types of analysis, starting with data cleaning, with criteria exclusion, anonymization, re-coding to a common scheme and indication of original language.

The next one is validity analysis, where the content validity was done using a pilot study, and the convergent and discriminant validity was confirmed using principal component analysis (dimensionality-reduction method), with Varimax rotation (statistical technique to clarify relationships among factors) and Kaiser Normalisation (method to obtain stability of solutions across samples). Bartlett's test (test for equal variances) and KMO measure (how much data is suited for factor analysis) were also used to validate data for factor analysis. For the analysis in changes and productivity, since the distributions were not normal, Wilcoxon signed rank test is used to compare them, and to estimate effect size, Cliff's delta with 95% confidence level. To test the remaining hypotheses, structural equation model (SEM, used to test theories involving constructs and uses a path modelling technique to build a model to predict) is used, which also uses confirmatory factory analysis. Weighted least square mean variance (WLSMV) estimator, which provides the best option for modelling, was also used for ordinal data.

This analysis is a very complex and complete one, which tries to address multiple concerns, but if the division of the analysis and the name of the subsections was better, it would be easier to accompany the topic.

Russo et al. [51]'s analysis consisted of two parts. The first analysis, which focuses on the time 1 data (first survey data), tests variables to explain the variance in productivity and well-being. Variance Inflation Factor (VIF) was used to test if multicollinearity caused any issue. On the second part, two multiple regression analyses, one with the well-being and the dependent variable and the other with productivity, were done with all the

variables that correlate to either one of those outputs, allowing to identify which variables are responsible for the variance. An analysis of the variables before the longitudinal study was done to select the ones that should enter the model by using Pearson product-moment correlation coefficient. In this case, the variables from time 1 that show to be correlated, are selected to be part of the model. The analysis of the longitudinal data make use of [Structural Equation Model \(SEM\)](#) to predict the outcome based on one entry predictor variable. The analyses were compared by using the [Standard Maximum Likelihood \(ML\)](#), [Robust Maximum Likelihood \(MLR\)](#) and [Multi-Level Estimator \(MLM\)](#).

Overall, it seems that most of the researches that analyse the difference between working in office and working in home, whether it is about productivity, benefits or challenges, make use of statistical methods, such as Wilcoxon rank sum-test to compare two groups, and Cliff's delta to estimate the effect size. Descriptive statistics can be used to describe the data, but does not provide differences between working in office and working at home.

7.6 Results

Having collected all the data from the population and then processed them and analysed them, conclusions and results can be gathered. These results should seek to answer the previously defined research questions.

The results found on Bao et al. [3] were (1) the impact of working from home is different on different metrics, (2) working from home has both positive and negative impacts depending on the programming languages, (3) the type of projects when working from home can affect negatively or positively, (4) working from home has a positive impact on older projects and negative in more recent ones, (5) the impact of working from home on larger projects is much larger than on smaller ones, (6) and the majority of developers maintain the same level of productivity when working from home, but there is a smaller portion where it has impact on it, whether positive or negative.

Bezerra et al. [6] found the multiple categories and relationships through grounded theory: (1) About the working environment, they found that external interruptions, adaptation, discipline and lack of awareness from families can cause negative impacts; (2) For the experience and skills, tasks, adaptation, communication and personal characteristics influence it. (3) Experience was found to impact positively the performance of tasks; (4) With organisation and collaboration, they found that collaboration and low turnover leads to positive productivity. It also found that the communication with stakeholders is either good or satisfactory; (5) Online communication tools has positive influence when working from home. The communication category has a relationship to stakeholders, with time (communication activities, both positive and negative), discipline (negative) and emotional (negative). (6) About motivation, emotional and health, the pandemic had a negative impact on some people's health. (7) Most people maintained their motivation when working from home. (8) The relationship with teammates did not change for most people. (9) As for the assistance from companies, the relationship between task and

emotional categories indicates contributions as a positive impact, and the relationship between work environment and communication points toward improvements made by companies. (10) The lack of assistance has a negative impact on productivity. (11) The work environment, tasks, time and displacement and a positive impact in self perception of productivity. It is actually interesting to see how multiple factors relate between themselves and impact each other, but there is a lack of consistency between results, since some state explicitly how it affects positively or negatively the productivity, while others do not. But the findings about the challenges and negative impacts corroborate the ones we found, as well as the influence of previous experience in remote work. It also underlines the importance of assisting employees, whether it is physically, mentally or in terms of equipment.

Butler and Jaffe [9] found that the challenges of working from home were feeling overworked, having too many meetings, low motivation and impacts on physical and mental health. But, the gratitudes they found were increased flexibility, more time with family, and increased mental health. Regular daily reflection on gratitudes for a period of time made a positive impact on both satisfaction and well-being of employees. There are some contradictions, in particular, the mental health being simultaneously a gratitude and a challenge, which could be better explained. While the research has a different approach, it shows that they found value in very similar benefits and challenges, such as impact on both physical and mental health, but also the gratitude towards the flexibility and more time with family.

The results by Camara et al. [12] focus on the benefits of the taken actions, which reflected on project quality and coordination, such as bug reduction, corroborated by the decrease of number of bugs found and the increase of the number of commits. It refers to the importance of communication tools and their centralisation, which led to replace face-to-face information exchanges and reduce uncertainties relate to project information. The actions certainly did not only affect the number of bugs and may have led to other improvements on the project beside that, so it would have been interesting to see more results.

Ford et al. [19] found that a substantial portion of the population initially decreased in productivity (32%-38%), but later there was an increase in productivity. It was also reported that the benefits were the lack of commute, spending more time with the family or focus in healthy habits, more schedule flexibility, fewer distractions and interruptions (more focus), personal comfort and better work environment. The benefits that made the most positive difference were better focus time, better work environment and fewer distractions or interruptions. Moving forward to challenges, they are the connectivity, distractions and interruptions, communication, lack of dedicated work environment, being always online, reduction of healthy habits, and having an unbalanced work-life balance. The challenges with the most negative impact were interruptions, lack of motivation and poor work at home environment. The improvements that could be made by companies were better hardware, improved connectivity, budget to improve home office, improved

communication tools, provision of ergonomic furniture, provision of guidance for work from home and support to remote work post-pandemic. Some challenges and benefits found are also present in our research, as is the case for the lack of commute, more time spent with the family, the negative impact of interruptions, unbalance between work and leisure, among others. It also confirms the increase in productivity that we found in our research.

Ganguly et al. [22] results are divided into 8 different sections, each containing several aspects related to it. In total, there are 24 aspects that can influence the productivity of software developers. The sections are (1) team dynamics, (2) company dynamics, (3) team collaboration, (4) access to resources, (5) work environment, (6) emotional well-being, (7) proximity to the COVID-19 virus, (8) and miscellaneous. All of these sections and aspects have an explanation and report if they changed positively or negatively, or if they maintained the same. The aspects that influence most positively the productivity are the activity level (related to emotional well-being), well-defined goals and team cooperation (team dynamics), number of task assignments (company dynamics) and frequency of communication (team collaboration). On the other side, the accessibility (access to resources) aspect and the sections of work environment and emotional well-being are the ones that do most of the negative impact. They reached a similar conclusion to ours about mitigating the drawbacks, which is by ensuring the necessary resources, suitable work environment and emotional well-being, the drawbacks can be mitigated.

Mendonça et al. [34]'s results are divided according to two different studies. The first study focuses on the impacts on the development of the system. The project management had a significant impact due to the discard of an implementation, and the distancing of stakeholders. The work practices of the development team were impacted, but it did not heavily affect the productivity, but made the team start working at unusual hours, which corroborates the changes in the working schedule that we found during our research. The results for the second study take a focus on the perception of the software developers and stakeholders on the impact of COVID-19 on the project. They found that developers did not think that changing to work from home compromised the expectations or the performance of the team, and that the sense of shared responsibility and collective ownership improved the performance of the team. As for the stakeholders, initially the main stakeholder expressed increased motivation, but down the line, the frequency of meetings between the developers and stakeholders decreased, which affected the project.

Oliveira et al. [40] found that the productivity changed for a major part of the respondents (75%), but for half had an increase in productivity. The productivity increases for ages between 30 and 45, while it decreases or stays the same for others. For those who have more than 10 years of experience, the productivity decreases. The productivity increased for those who work at companies with over 100 employees. Regarding the communication tools, Skype, WhatsApp, Zoom and Slack fulfil most of the communication needs, and those who had to learn more tools had an increase in their productivity. Finally, the software developers had to adopt informal communication mechanisms to

facilitate the coordination of activities. To most of the respondents, companies asked them to stay online during their working hours, but most did not use any software to track productivity. More than half of the participants would enjoy working remotely after the pandemic, which confirms our findings about the majority of the people wanting to work hybridly post-pandemic.

Out of all Ralph et al. [45]’s hypotheses, only two were not supported, the ones related to the impact of fear. One of the hypotheses related to the change on well-being and perceived productivity being directly related. The other, is about the change on perceived productivity depending on home office ergonomics and disaster preparedness. Some direct findings related to ergonomics were that people with small children or disabilities have less ergonomic offices, while people who live alone have better. Women, people who are isolated, have disabilities, have COVID-19 or a family member has it, tend to be more fearful. People who live with other adults are more prepared to disaster than those with disabilities.

Russo et al. [51] found that many predictors are correlated to the well-being, and actions that should be taken to address them. These factors are: (1) autonomy, a positive predictor, and the recommended action is that companies should trust enough freedom to employees to schedule their day, (2) stress, the only negative factor, and it is recommended to practice stress reduction techniques, (3) daily routines, a positive predictor, and it is recommended to establish new routines, such as hobbies and social contacts, (4) social contacts, also a positive predictor, and the recommended action is to establish informal meetings, (5) competence, a positive predictor, with the recommendation that companies train software developers for remote working, (6) extroversion, which has the lesser positive impact, and introverted people should be reached out; (7) and quality of sleep, a positive predictor, with the recommendation to schedule enough sleeping time. As for the predictors related to the productivity, there are only two significant, both negative, which are boredom and distractions. While we did not find mentions of boredom during our interviews, we reached the same conclusion about the negative impact of distractions. The recommendations for the first is for companies to allow employees to choose as many goals as possible, and for the latter, support software developers setting up a home office. These recommendations are in accordance with what we found and the recommendations we found fit to address some of the issues.

Overall, it seems that the challenges most commonly found are the lack of help from companies to set up a home office, distractions and interruptions usually impact negatively. But less commuting, more schedule flexibility and more time spent with family affect positively. Different projects and personal characteristics can also impact differently an individual.

Table 7.1 summarises all of the related works that were analysed, where each column corresponds to one of the previous sections, and each row to one of the related works.

Table 7.1: Summary and comparison of the related works analysed.

Methodology 7.1	Num. Participants	Roles	Countries	Research Questions 7.3	Interview & Surveys 7.4	Data Analysis 7.5	Results 7.6
[3], 2020	139	Software Developers.	China	Differences in productivity when WFH; Impact of projects characteristics; Perceived productivity when WFH;	N/A	N/A	Impact of WFH depends on the metrics; WFH has both negative and positive impacts; Characteristics of projects can impact both positively and negatively; Most maintained productivity, but there are people who decline in it.
[6], 2020	58	UX/UI Designers; Software Developers; Requirement Analysts; Project Managers and Testers.	Brazil	Impact of WFH on productivity, motivation and emotional; Influence of experience and skills; How communication, collaboration and organization occurs during COVID-19; How companies assisted their employees;	X	Descriptive statistics, describe basic features of data; Open Coding and Axial Coding (CT) to generate categories and relationships among them.	The WFH environment had to be adapted; Distractions cause emotional distress; Experience impacts positively; Communication tools have mostly a positive impact; Negative impact on health;
[9], 2020	435	63% Software Engineers; 17% Project Managers; 2% Administrators; 6% Others (Designers, Big Managers, and more).	Worldwide 80% USA 14% Asia 3% Dablin 3% Others	Challenges when WFH during pandemic; What are the points of gratitude; Impact of regular reflection on gratitude in satisfaction and well-being.	X	Thematic qualitative analysis to find themes, key concepts and commonalities.	Challenges were being overworked, low motivation, too many meetings and impact on health; Gratitude were more flexibility, time with family; Reflections had a positive impact on satisfaction and well-being.
[12], 2020	9	1 Scrum master; 1 Product Owner; 1 Technical Leader; 6 Developers.	Brazil	How do agile software development startups approach uncertainties caused by COVID-19.	N/A	N/A	Reduction of number of bugs and increase in commits; Centralization of communication tools is important;
[19], 2020	1st: 1.350 2nd: 2250	70% Software Developers (1st) 30% Program Managers (1st) Data Scientists (2nd).	United States of America	How has productivity changed when WFH; What are the benefits and challenges of WFH, how they impact productivity; What recommendations should be made to companies	X	Thematic qualitative analysis and open-coding; Wilcoxon rank-sum test; Fisher Exact Value tests to test for significant differences; Benjamini-Hochberg procedure to reduce false positives rate; Least absolute shrinkage and selection operator (Lasso) to select relevant variables;	Substantial decrease in productivity, but an increase later; Benefits are better focus time, better work environment and more focus; Challenges were interruptions, lack of motivation and poor home work environment; Improvements were better hardware and ergonomics, provide guidance for WFH and support WFH post-pandemic.
[22], 2020	N/A	N/A	Bangladesh	N/A	X	Descriptive statistics analysis on each factor.	Activity level, well-defined goals and team cooperation, number of task assignments and frequency of communication impact the productivity positively; Accessibility, work environment and emotional well-being have the most negative impact; By ensuring the necessary resources, suitable work environment and emotional well-being, these problems are mitigated.
[34], 2020	9	Single software team: 2 Software Developers; 2 Stakeholders; 1 UX/UI Designer; 1 Software Architecture.	Brazil	What practices have changed with WFH; What challenges and risks COVID-19 imposes on projects; What are the perceptions of team members and stakeholders on the impact of COVID-19.	X	Transcription of interview to verify all the information.	Project management, work practices of requirements team and development teams were impacted negatively; Developers do not think that WFH compromises expectations and performance; Stakeholders felt more motivation initially, but the frequency of meetings declined.
[40], 2020	413	75% Software Developers; 9.2% Product Owners; 6.54% Data Scientists; 3.14% Testers; 6% Others.	Brazil	Did productivity stay the same during COVID-19; Which communication tools were used; If the number of tools to adopt correlates to an increase of productivity; Did development processes change to reduce necessary communication?	X	Not disclosed, but an analysis of the distribution of the data per questions is done, as well as using graphics that relate multiple variables.	75% of the participants productivity changes, either positive or negative; Different ages have different changes on productivity; Experience influences how productivity changes; Skype, WhatsApp, Zoom and Slack are the most complete communication tools; Adoption of informal techniques to facilitate communication; Over half of the participants would enjoy working remotely after the pandemic.
[45], 2020	2225	80% Software Developers; 22.7% Others (Project Manager, Quality Assurance Analyst).	53 Countries 22.7% Germany 16.4% Russia 2.2% Brazil	How WFH during the COVID-19 pandemic affects developers' well-being and productivity;	X	Component analysis; Varimax rotation; Kaiser Normalization; Bartlett's test; KMO measure; Wilcoxon signed rank test; Cliff's delta; Structural equation model (SEM); Weighted least square mean variance (WLSMV) estimator	Changes in well-being and disaster preparedness are not related to fear; Well-being and perceived productivity are related; Perceived productivity depends on home office ergonomics and disaster preparedness; People with small children or disabilities have less ergonomic offices; Women, people who are isolated, have disabilities, have COVID-19 or a family member has it, tend to be more fearful; People who live with other adults are more prepared for disasters.
[51], 2020/2021	1st - 192 2nd - 184	Software Engineers	Worldwide 33% UK 27% USA 10% Portugal 30% Others (EU)	What are the relevant predictors of well-being and productivity when WFH during a pandemic;	X	Variance Inflation Factor (VIF); Pearson product-moment correlation coefficient; Structural Equation Modeling (SEM); Standard maximum Likelihood (ML); Robust maximum Likelihood (MLR); Multi-level estimator (MLM).	The positive predictors of well-being found were: autonomy, daily routines, social contacts, competence/striverson, and quality of sleep. Stress is the only one negative; There are no positive predictors for productivity, and the negative ones are: boredom and distractions.

7.7 Other studies

This subsection is about related works that might not share the same concerns about software developers' productivity or that are not conducted in a company context. The topics to be addressed are related to the **on-boarding during the COVID-19 pandemic**, two researches on **GitHub productivity**, and one about **how the COVID-19 pandemic disproportionately affects women**.

7.7.1 Please Turn Your Cameras On: Remote Onboarding of Software Developers during a Pandemic

Rodeghero et al. [49]'s research approaches on **how onboarding was affected with the COVID-19 pandemic**. With the transition from physical offices to work from home, companies did not have enough time to adapt their onboarding processes and, as such, the paper explores how onboarding changed and the gap that exists in literature. It also focuses on how onboarding processes can be improved.

The methodology for this research is very similar to Ford et al. [19]'s first survey, with the usage of an online survey with the design based on software development during COVID-19 and remote work in general. A survey pilot was done, and the final survey was sent to 1000 new hires, and used coding for data analysis.

The population of this research are 267 new hires that onboarded on Microsoft during the COVID-19 pandemic, corresponding to a response rate of 26.7%. All of the population were professional software developers, newly hired and full-time employees. Out of the 267 participants, 60% were of the male gender, 21% women and 19% did not answer the gender or are non-binary. 140 were industry developers, 38 college hires, and the remaining are either college or industry developers with previous experience at Microsoft. All of the population was from the United States.

The research questions addressed were (1) what challenges are found during onboarding, (2) what are team doing for onboarding new hires, (3) how do team members interact with new hires during the pandemic, (4) and if new hires feel socially connected to their team.

Some of the questions that were asked in the survey were about challenges new hires faced, the efforts of teams with new hires, how is their communication and what new hires do to stay connected with their team.

The open-ended questions analysis is realised using open-coding, the code themes were discussed, and a code book for each question was compiled.

The challenges found were that communication and collaboration with teammates is harder, struggles to ask for help and build team connections, finding documentation, dealing with technical issues and difficulty acquiring hardware and permissions. The efforts done by teams to mitigate some of these challenges were to have frequent 1-on-1 meetings with the manager, held remote meetings for new hires on their first day, ensure

they are not blocked on a task, hold social remote events to get to know each other and the usage of onboarding buddies. The interaction with the team was found to be majorly work-focused topics, with the communications lasting less than half an hour. Despite all the difficulties, 83% of the new hires felt connected to their teams, and made an effort to maintain social connections.

Albeit some challenges existed previously, it was found that remote onboarding can amplify them and be more impactful, and that collaboration and communication challenges are mostly related to COVID-19. Some efforts might not make some new hires feel connected to their team, since not all of them have the same opportunity for it.

The recommendations left by the authors for the companies are (1) promote communication and asking for help, (2) encourage teams to turn cameras on, (3) schedule 1:1 meetings, (4) assign an onboarding buddy/technical mentor and more.

7.7.2 Octoverse spotlight: An analysis of developer productivity, work cadence, and collaboration in the early days of COVID-19

On May 2020, Forsgren [21] published an **Octoverse report on GitHub**, which provides trends and insights in developer activity, dedicated to the COVID-19 pandemic. Based on the available data to GitHub, they centre the report on three themes: **productivity and activity, work cadence and collaboration**.

For the first theme, they analyse the activity of developers on GitHub, both on private and public repositories. Looking at the graph they present, most continents increased their activity, with the exception of North America. This is confirmed by the increase of pull requests, pushes, reviewed pull requests and comment issues per user. After the initial lockdowns, the number of issues created by each user and issues per active user had an increase, indicating the resuming of developing activities after the work from home transition.

The second theme, work cadence, is analysed through the paid organisation accounts. By analysing the time interval between pushes, it allowed to understand that developers are working the same hours, but in smaller shifts, due to non-work interruptions. Also, when looking at the work volume, it was concluded that developers are working longer days.

For the last theme, collaboration, using also the data from paid organisation accounts, when looking at the time to merge pull requests, it decreased, meaning that more people were online and ready to review pull requests. The open source projects are also analysed through the same metric. The time to merge pull requests also dropped, due to more people engaging in open source projects, since there are more projects they can do from home.

On a last note, the author warns companies about an increased likelihood of burnout, since developers are working longer, with more work and more responsibilities. It also

encourages companies to allow more flexibility on their employees, and embrace collaboration and the open-source culture.

7.7.3 A Deep Dive on the Impact of COVID-19 in Software Development

Mota Silveira Neto et al.'s research [36] takes a mixed approach on the **impact of COVID-19 in software development**, by conducting a **mining software repository study**, and using a survey to better understand the results of the first study.

The methodology was composed of a repository selection, where repositories were selected according to multiple inclusion criteria and exclusion criteria. After, the mining is realised, four metrics are obtained from cloning the repositories, while other four are obtained through the API. After that, the survey was created and a pilot survey conducted, to evaluate it. The data of the survey and the mining were analysed differently, allowing to gather different results.

The population of the study are 100 Java repositories, while for the survey, the population was gathered from social media, resulting in 279 respondents, with the top three countries being Brazil, United States and Germany. The average for professional experience was 12.5 years, with a median of 10 years. 34% of the participants work in companies with 1000-9999 employees, and 23% on companies with 100-999. 82% of the respondents have a degree, 95% are paid, 90% work full time and 94% have no disability. Most of the participants worked in office before the pandemic (82%).

The study has two research questions, one about the impact of COVID-19 on the projects, and another about the impact of COVID-19 on the developers' well-being.

There are 20 questions contained on the survey, most of them using a Likert-scale. 12 of the questions are about demographics, one question with multiple statements about productivity and performance and its answers based on Likert-scale, and three open-text answers, two about how the participant coped with the effects of COVID-19 on productivity and well-being.

The analysis of the mining part was done with a time series analysis, where each metric is calculated over six time-windows, to see how they changed between each frame. A pairwise two-sample t-test was also performed to evaluate if there were any significant differences in the mean of the metrics between each frame. Both the analysis and the survey can be found on GitHub [43].

The results of the mining study reveal that there was a decrease on commits and pull request comments, while the results of the survey show that developers disagree with it. Other results that were found were that the code contribution, overall productivity, task completion time, code quality are either not impact or do not decrease. The results about the well-being are on-par with some of the previous researches, meaning that in the short-term, some participants feel more stressed, sleep less and overall have a decrease in well-being. In the medium to long term, these can diverge.

7.7.4 UNESCO Science Report and The impact of COVID-19 on women scientists from developing countries: Results from an OWSD member survey

The UNESCO science report 2021 [5] approaches the lack of inclusivity of women in jobs and **how the COVID-19 pandemic affects more women** in science and engineering than men. They refer that according to multiple initial surveys, they have less job security, decline in their research time, less publishing rate and comment less on television when compared to their male counterparts.

On June 2020, the Organisation for Women in Science for the Developing World (OWSD) surveyed women in the science and engineering areas to evaluate the impact of COVID-19 on them and their research [28]. The pandemic lead to a disruption in the researches, with the most negative impacts being not being able to travel to conferences and events, interruptions in experiments or field work, teaching duties and publishing delays. The delays or suspension in funding caused difficulties in finding collaborators, being unable to submit funding proposals or publications, missing out business opportunities or clients, and more. The survey also reports that women are actively participating in the pandemic researches, whether it is about finding solutions, researching the COVID-19 virus, studying the impact in health, society and economic, and more. 44% of the respondents had to cut their working responsibilities to assume other responsibilities, such as childcare, homeschooling and household chores, while others found positive impacts such as a more flexible schedule, expand professional skills and experience, augment scientific publications and more.

This survey and report seem to meet what some previous related works, where women in software engineering were more affected by the COVID-19 pandemic than men, and shows that the difference applies to other scientific areas.

CONCLUSION

By conducting interviews and applying the Straussian Grounded Theory, we were able to characterise the multiple impacts of the COVID-19 pandemic on the productivity of software developers through a theory which is composed of 16 categories and 18 relationships.

In total, we interviewed 20 Portuguese people. Most of them are software developers, have between 20 and 40 years, predominantly male, and have between 0 and 12 years of experience.

From the categories, we were able to determine that the challenges found by software developers during the pandemic were the distractions caused by the home environment, which can be caused by other people or environment noises; The lack of social interactions, since people felt more socially distanced and isolated from others.

We also found that there was something underlying all these challenges and issues, which are the lockdowns. Since everyone was restricted to their homes, and with a high probability of working remotely, it caused the distractions and problems of the shared space that we just identified. But despite everything, companies and employees alike were able to adapt and overcome some of these difficulties.

The collaboration and communication had a particularly positive impact in the software development, as it contributed to allow one to do their work, but also had a positive impact on the mental health.

The changes of the working space during the pandemic, brought both challenges and benefits associated with the home environment. Working in an office during the pandemic proved to have a very negative impact, as it caused people to feel afraid and uncomfortable of the COVID-19 disease. While the working space has both negative and positive impacts on productivity, the positive ones end up out weighting the negative ones, since it is possible to address some of them.

The equipment is now more important than ever, since it is necessary for one's work. Overall, it was not a big issue, since companies either provided the equipment or offered to pay for equipment acquisition.

The Knowledge Sharing was still extremely relevant during the pandemic, and it is

still done regularly, with sometimes other teams participating in it. As such, it ends up having a positive impact in the communication and collaboration during the pandemic, as it promotes both.

The concern regarding mental health was one of the biggest topics of our research and one of the most important ones. Now, more than ever, software developers are more prone to burnout, as it is easier to hit it, and social isolation makes it easier for the burnout symptoms to go unnoticed for longer. The burnout stage has a negative impact on a software developer. The promotion of mental health was found to be important and necessary, either through social initiatives (meetings, social events and others), or with facilitated access to psychologists for employees, as it eases some underlying issues.

Along with mental health, physical health was also a concern, since software development tends to be a sedentary job. We found that the promotion of physical health, either by online exercise classes or in person social events have a positive impact on preventing the appearance of serious health problems that a more sedentary pandemic lifestyle can cause (e.g. back problems, tendinitis, among others).

The pandemic had companies adopt new tools and technologies to meet the new needs, which reflected on people learning new technologies in the work context.

The way one works has changed with the pandemic, and with it also has the working hours, although throughout an entire day, the total number of hours worked ends up being the same as before.

About the online social events, they were important since they allowed people to communicate in a more informal way and interact, which addresses some social isolation issues that existed during the pandemic. They also helped one to adapt to the pandemic, by giving that necessary social factor, and as such, they had a very positive impact.

Software development did not change significantly with the pandemic, as processes for it were already implemented before. This means that project deliveries and others tasks happened normally, and there was not a huge impact on it.

As for the privacy, it did not have a negative impact during the pandemic, since most people were not controlled by their company.

Despite everything, the benefits of working from home during the pandemic outweigh the challenges, as we found that there was actually an increase in productivity of software developers.

From all the observations and different impacts presented in our theory, we found a set of recommendations for the post-pandemic based on our findings. These recommendations are done with the goal to address some of the concerns that might exist post-pandemic, in order to increase overall health and well-being, and increase the software developers' productivity in a context of remote work after the adaptations.

Our recommendations for the companies which are expecting to keep providing a remote work model in the post pandemic are the following:

- **Allow flexibility in how the remote work is planned**, allowing employees to work

from home or work at the office when they need;

- **Trust your employees** work capacities when working from home;
- **Guarantee that employees have the necessary conditions and equipment for their work.** Also offer help with acquisitions that contribute to their well-being when working;
- **Provide mental and physical health help** in the form of psychologists, exercise classes and other initiatives;
- **Promote social events**, both online and in person, as they promote communication and have a positive impact;
- **Allow flexibility** in terms of **working schedule**;
- **Promote communication and collaboration**, and facilitate the communication between teams;
- **Avoid work in person in a future pandemic**, since it has a big negative impact and causes discomfort to employees;
- **Invest in Knowledge Sharing and documentation**, as it has a positive impact;
- **Pay special attention to employees who are parents**, and understand their context.

Lastly, through this research we concluded how the pandemic had several impacts on the software developers' productivity, and how it changes depending on the person's context. We also concluded that it is important to invest in the well-being and health of the employees. If companies invest to ensure that they are able to help when needed, make employees feel well, and ensure that they are doing well, the employees are happier when working, are healthier, and in turn, they are more productive.

8.1 Answering Research Questions

In our initial [chapter 1 – Introduction](#), we defined an initial main research question, and the several research questions that compose it. Having presented our theory and discussed the many details of it, we are now capable of answering some research questions.

RQ-Main: How did the COVID-19 pandemic impact software development?

A-Main: The impacts of the COVID-19 pandemic vary depending on a software developer's context. Overall, it has both positive and negative impacts depending on what one looks at. The work space, working in person during the pandemic, the burnout and

distractions have a negative impact on software development. The communication, the collaboration, the knowledge sharing, working space, social events and promotion of social events have a positive impact.

RQ1: How did the pandemic affect software development teams?

A1: In terms of development, the development process was not affected, with the only change being that is now done in a fully online format. For the QA Analysts, UX/UI Designers and Managers, further research is necessary.

RQ2: What did companies do to mitigate potential challenges in development teams?

A2: The companies were able to mitigate the challenges of development teams during the pandemic through the promotion of physical and mental health, through provide the necessary equipment and monetary help, promotion of communication and collaboration.

RQ3: How does the impact other teams reflect on software development teams?

A3: The impacts of the COVID-19 pandemic on other teams, whether they are other development teams or not, did not translate into any impact on the software teams.

RQ4: What are the potential benefits of working remotely and hybridly?

A4: Working remotely allows one to avoid traffic, which benefits the mental health and well-being. Not having to commute to work increases people's personal time. All of this benefits the productivity positively.

RQ5: What guidelines can be given to companies that want to support full or hybrid remote work after the pandemic?

A5: As previously said, allow remote work and work schedule flexibility, provide mental and physical help, trust the employees, promote communication, collaboration, knowledge sharing and social events.

We are unable to answer the research question regarding what changes companies expect for the post-pandemic, since we interviewed a low number of CEOs, and thus, we were unable to find any conclusion.

8.2 Future Work

While this research tried to also understand the impact of the pandemic in the other software development teams (Quality and Assurance testers, UX/UI developers, among others), we were unable to interview enough people to reach conclusions about those specific roles, and thus, it would be interesting to conduct researches that follow up this one about those specific roles.

Another possible future work would be one that focuses on the impact of the pandemic on the onboarding. During our interviews we had indications that it actually became harder, but we were unable to interview enough people that went through the onboarding process during the pandemic, and as such we were unable to get enough details to draw conclusions. That research could focus on how the process changed with the pandemic, how it impacted the developer, among others questions.

An interesting future work would be the conduction of a complementary research that also makes use of the Grounded Theory, but uses a different method for data collection. An example would be a Grounded Theory research that uses a questionnaire to gather data.

Last but not least, an interesting follow-up future work would be in the post-pandemic, to revisit this research and re-do the interviews and see how much it changed, if the same challenges and benefits still exist, and if new ones appeared, and possibly understand even better the real impact of the pandemic.

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BASE INTERVIEW QUESTIONS

The following questions are the base questions we defined to be asked in all of the interviews. Depending on what the interviewees said, more questions were done given the chance.

General

- How many years of experience in your area do you have?
- What type of company do you work at?
- What is the size of the company?
- What is your role in your company?
- Do you live with other adults? How many? How do they affect your productivity?
- Do you have children? How many? How did having your children at home affect your productivity?
- Do you or anyone in your household have a disability? How many? If you do, how does it affect you when working from home?
- Do you have previous experience in working remotely? For how long? Did that previous experience help you adapting to full remote work during the pandemic?
- If you have experience working remotely, what changes to remote work did you observe?
- Do you think the pandemic and the full-remote work changed your employer's and colleagues' thoughts about remote work?
- Do you have a dedicated space for working?
- Did you have to buy any type of equipment for your home office? What kind of equipment did you have to buy?
- Did your company help you paying the acquisition of work equipment?

- Did your company host online social events? Which? How did they help you adapt to the pandemic? What is your opinion about them?
- Would you consider that previous distractions were good/useful distractions? (e.g: Grab coffee leading to informal communications, which helps unlocking ideas, among others)
- Do you consider that the distractions from working from home have a negative impact (Caused by family, chores, among others)?
- What challenges did you find in the pandemic remote work? What did you try to mitigate them?
- How was your productivity affected during the pandemic?
- How is the collaboration within your team done? And with other teams done?
- Is knowledge sharing done frequently in your team? Are other teams included in it? How is it done? What is the impact of Knowledge Sharing during the pandemic?
- Did you feel more prepared for the lockdown(s) that followed?
- Did you work in person after the first lockdown? How was your experience?
- When working remotely, do you feel like you have less privacy, whether it is digital privacy or real life privacy?

Developers

- How was the development process done pre-pandemic?
- Did the development process change? How did it change?
- Did some of the steps of development become easier/harder? Why did they?
- Did you find yourself working more/less hours? Why?
- Did you have to adopt new technologies? Which ones and why?
- With more schedule flexibility, would it make sense to abandon time sheets and other effort control procedures?
- Did you have to adopt new technologies? Why?
- How did the communication with your team change?
- Did you observe that the impacts on other teams somehow impact your team?
- Have you taken time to learn new skills and experience that might not be used in your work?

-
- Is your productivity measured on your company? How?

Managers

- What changes in your role did you observe?
- How does the working remotely affect the trust level on employees? If it decreased, how did you address the decrease of the trust level?
- How did you try to address teams'/projects' challenges?
- Do you feel that stakeholders are more/less available? Is the communication with them easier/harder?
- Did the requirement capture change with the pandemic?
- Do you measure teams' productivity? How?
- Did the overall teams' productivity increase, decrease, or stay the same?
- How was the onboarding process adapted to the pandemic remote work?
- What are the desirable aspects of a team to make remote work work?
- Should requirements be even more concise and direct to allow less doubts?
- How has the allocating of resources changed with the pandemic?

UX/UI

- Has the pandemic made the communication with other teams more difficult?
- How did the process of design change?
- Do you have any experience with programming?
- Did you have to learn new technologies and/or programming languages to facilitate the communication with development teams?

QA Analysts

- Did the quality assurance process change? How did it change?
- Has the pandemic made the communication with other teams more difficult?
- How did the quality in the developed software change?
- Did it become more difficult to test software?

CEO

- Did you reduce the office's size? If so, what did you do with extra equipment?

- Did you provide equipment for remote work? What type of equipment you provided?
- From the moment you learned that the company was going to be forced to work remotely, what decisions were made and with whom?

Health/Well-being

- Do you feel like it is easier to hit burnout?
- Did your company do something to try to improve your physical health during the pandemic?
- Did your company encourage good mental health practices to the pandemic? What practices?
- Would you like if your company provided easy access to therapists or psychologists?

Post-pandemic

- **General Questions (excl. CEO)**
 - Would you like to keep working from home post-pandemic?
 - Between fully remote work, hybrid remote work, and rotation remote work, which would you prefer and why? Did you already think about that possibility before the pandemic?
 - If a set of new regulations or laws are created to be applied to remote work, if it becomes the new working reality, what do you consider important to be in them?
 - Would you appreciate if your company helped paying your electrical bills or ISP bills?
 - Do you think it would be harder to progress in your career if you worked from home post-pandemic?
 - If your company allowed you to buy second-hand office equipment at a discounted price, would you do it? Which kind of equipment?
 - Would you like online social events to continue?
 - Do you think that there is a conflict of interests between employees and employers about the future of remote work?
 - Do you think there will be more job insecurity in the post-pandemic?
- **Developer Questions**
 - With the remote work becoming more common, would you be more open to GSD, Nearshore or Offshore?

-
- Would you be willing to work from home, but having to travel regularly to other country (e.g Onboarding)?
 - Which development practices changes would you like to see continue to be used after the pandemic?

- **CEO**

- If you plan on allowing fully remote work or hybrid, will you leave or change to smaller offices with the pandemic?
- How much time do you expect to be spent in offices?
- How do you feel about supporting your employees by helping pay electrical and/or ISP bills?
- Do you plan to promote mental/physical health in the post-pandemic?

ANNEX 1 - CATEGORIES MENTIONS PER INTERVIEW

	E00	E01	E02	E03	E04	E05	E06	E07	E08	E09	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19
Remote work experience pre-pandemic	✓	✓		✓			✓			✓	✓	✓			✓	✓	✓	✓	✓	
Lockdowns	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	
Distractions	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Colaboration	✓	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	
Communication	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Challenges	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Working Space	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Equipment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Knowledge Sharing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mental Health	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Physical health	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Working Hours	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Technologies and skills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Productivity	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Social Events	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Global Software																				
Development, Nearshore, Offshore	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓			✓		
Development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓		
Privacy				✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓		✓		
Onboarding					✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	
Conflicts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓
Regulations and costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Progression and stability	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Remote work changes	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Remote work benefits					✓	✓											✓			
Remote work expectations post-pandemic	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Roles ¹	✓								✓				✓	✓		✓				✓

Table I.1: Code mentions per interview

¹Since listing each individual category role that is not a software developer would only indicate who belongs to it, we decided to group them into a singular row, Roles, which is not an actual category.

| II

ANNEX 2 - SUMMARY OF THE THEORY
CATEGORIES

Category	Sub-category	Code	Quote
Lockdowns	Evolution of lockdown adaptation	More preparation for lockdowns	<i>"Yes, after the first one I'd say that from now forward is much easier because we know better what expects us."</i> [E1]
	Impact of Distractions	Negative impact of distractions	<i>"Yes, it is a very big impact on performance and productivity."</i> [E2]
Distractions	Avoid Distractions	Make other people aware of distractions	<i>"(...) I never had problems thankfully, everybody where I live thankfully respects each other's time and space, and so I was able to work comfortably in a little space that I got precisely just for work."</i> [E6]
	Types of Collaboration	Asynchronous collaboration	<i>"(...) we have communication totally asynchronous like Wikipages, email and that kind of stuff(...)"</i> [E18]
Collaboration		Semi-asynchronous collaboration	<i>"So there's the basic, we have the written communication semi-asynchronous, like Slack (...)"</i> [E18]
		Synchronous collaboration	<i>"If anyone needs help, we make a call on Teams, we share our screen if it is necessary to see code."</i> [E10]
	Tool usage for collaboration	Tools transversal to company	<i>"In the same way that Mattermost is transversal to the whole company lets say (...)"</i> [E6]
		Alternative tools for informal collaboration	<i>"(...) we use Discord to sometimes give company to each others, when it is needed to talk and say day to day things (...)"</i> [E3]
	Types of Communication	Asynchronous communication	<i>"Focus on the asynchronous, a lot more, and we were not used to that, and now it is much more asynchronous (...)"</i> [E17]
		Semi-asynchronous communication	<i>"The communication is now done more often through Slack, in terms of warnings or draw attention (...)"</i> [E17]
Communication		Synchronous communication	<i>"(...) I think that with the pandemic there are more Zoom calls (...)"</i> [E17]
	Impacts on communication	Realisation of communication importance	<i>"(...) I am at home at permanent contact with people of my team, and others teams, that yes was particularly important (...)"</i> [E14]
	Less communication during the pandemic	Distance from other people	<i>"(...) after a while people started to feel a bit more distant during the pandemic(...)"</i> [E17] <i>"(...) I stay out of contact with them for a while (...)"</i> [E0]

Category	Sub-category	Code	Quote
	Tool usage for communication	Dedicated spaces on platforms	“(…) we have a variety of channels that are divided, for example, we have team-general, a chat for engineering, one to talk with data science (…)” [E3]
		Tools transversal to company	“(…) Mattermost lets say that it is transversal to the whole company (…)” [E6]
	Internal Communication	Surveys conduction to inquire employees' state	“(…) we did a first survey, a survey transversal to the whole company with a series of questions on how people were feeling, if they felt like they were performing as before, just to have an idea of the questions, if they felt like their productivity had increased or decreased, if they felt any difficulty (…)” [E8]
	Work in office during the pandemic	Worked in person during the pandemic	“Yes, when offices started to open, somewhere between July and august, we would go [to the office] one or two times per week to socialise with the team.” [E17]
Work Space	COVID-19 prevention for physical access	COVID-19 prevention measures	“(…) we were separated, we have a gap between us in the desk, and all of us use a mask inside the office (…)” [E2]
			“All of the rooms had a limit of number of people who would be inside it (…) they gifted all of us a personal hygiene and cleaning kit, with a mask and disinfectant (…)” [E6]
	Harms of working in person during a pandemic	Discomfort of face-to-face work during pandemic	“(…) I felt very uncomfortable in terms of having to use the mask essentially during the eight hours that I am in here (…) during the lunch time it was another moment where I did not feel comfortable (…)” [E6]
	Work Space utilisation	Separated but not dedicated space	“More or less, I work in my bedroom, in the place where I have my leisure computer, so the computer that I use to game, and it is on that desk that I work, I do not have a dedicated office for me in this house.” [E18]
		Dedicated space	“Yes, I have a room that is a office.” [E10]

Category	Sub-category	Code	Quote
		Not separated and not dedicated space	"Not properly, I use the living room [to work]." [E7]
	Distractions caused by space sharing	People as a distraction	"My mom sometimes comes here to talk (...) sometimes I give her a bit of talk and I get distracted." [E0] "(...) while I was working at home she was at home, typically she had online classes and she is on the third year for the first time, I had to help her with online classes (...)" [E11]
		Noise as a distraction	"(...) a random background noise, or if people are talking, that immediately makes a bit of interference." [E7]
	Challenges caused by the working space	Difficulty in separating leisure from working space	"But that was something that I felt that was harmful, not having that space well, it wasn't as easier to separate work from other tasks, and maybe it put a bit of a mental barrier to really stay inside the work mindset."
	Decentralisation as a benefit	Less time lost in transit	"It increased a lot the personal time, because I would have to do home tasks either way, I end up saving commuting time and at lunch I still have time to do some things after." [E0]
		Decentralisation of big cities	"(...) and it does not create the overcrowding that we have at the moment in big cities like Oporto and Lisbon, where the prices of houses are rising like crazy, there is hellish gigantic traffic (...)" [E3]
Equipment	Material acquisition	Company provided equipment for teleworking Company provided monetary help for acquisition Company did not help paying material expenses Acquired equipment during the pandemic	"(...) besides that, the company in particular allowed and encouraged people to get the equipment they needed from the office (...)" [E14] "My company gave a voucher of value X to its employees if they wanted to buy a more comfortable chair, a decent desk, which helps (...)" [E9] "No [they did not help acquiring equipment], although it gave me a monitor and a laptop, besides that no" [E4] "(...) I bought a better chair, a new keyboard and a better mouse (...)" [E10]

Category	Sub-category	Code	Quote
Knowledge Sharing	Knowledge Sharing Formats	Presentations and meetings	<i>"Yes and during the pandemic we continued doing our presentations, and stuff that we also had, so yes, it continues." [E6]</i>
		Asking and solving questions	<i>"(...) if any kind of problem exists, we help each other, to correct that stuff and be able to advance (...)" [E7]</i>
		Usage of technologies	<i>"(...) there has been a bit more of effort to have more written documentation (...)" [E18]</i>
	Knowledge Sharing Occurrence	It is done regularly	<i>"Yes, it is done more or less in the same way it was done in office, but in a digital way (...)" [E18]</i>
		Participation of other teams in the Knowledge Sharing	<i>"No, normally when we need someone to transmit us knowledge is when we call the person, but it is not always." [E16]</i>
	Changes in the Knowledge Sharing process	Knowledge Sharing requires more logistics	<i>"Maybe it is a bit harder because it requires more logistics to share that stuff (...) here we have to make a call, make a share, only one person at a time can share, so it is a little bit more rigid in that aspect." [E3]</i>
		Positive Impact	<i>"Yes, because the better knowledge sharing is, better it is for people to unlock all the necessary context, because there it is, since the pandemic impacts a lot the interaction with people and asking for help, if people have all the knowledge they need and are able to advance alone, that is always the best." [E17]</i>
	Impact of Knowledge Sharing	Knowledge Sharing important despite the context	<i>"I think despite working remotely or not, the impact would be the same, because in both cases it is good to have feedback between all of us, know what is going on, where we stand, so that we can move forward (...)" [E7]</i>
		Easier to hit burnout	<i>"Without a doubt [it is easier to hit burnout], I think there's also a whole outside context that I felt in both the first lockdown and in the January one, where with the COVID-19 cases rising affected a lot my concentration in a lot of moments, there was a fear factor associated that affects us and might [more easily] lead us to burnout." [E11]</i>
	Mental Health	Burnout during the pandemic	

Category	Sub-category	Code	Quote
		Difficult separation of work and leisure	<p>"I think so because I think to avoid burnout it is necessary to have a change of scenery, and the easiest way for that is to change space, and without being able to leave home, that's more complicated (...)" [E6]</p> <p>"(...) We no longer have that routine where we have to prepare ourselves that what we are doing is working, and then no longer it is (...) and now that everything is done in the same space, (...) where it is leisure or work, (...) everything looks the same (...)" [E0]</p>
		Negative impacts on mental health	<p>"(...) the biggest challenges were being able to adapt to always remote without having to talk with people (...)" [E12]</p> <p>"(...) I was closed at home, working in front of the computer, I would not see anyone because I did not have regular calls (...) I ended up being very lonely (...)" [14]</p>
		Promotion of mental health	<p>"The company provided the conditions for a health insurance to its employees, and in that insurance that is contemplated yes." [E4]</p> <p>"A lot, it promoted a lot but really a lot of workshops, seminars that were presented by people from the mental health area, with a questions and answers segment, about several themes, whether it was about distance, virtual collaboration, burnout, what is working remotely like, so a lot of different themes, all associated to this that [mental health] main topic." [E13]</p>
		Access to psychologists	<p>Psychologists as a form of help</p> <p>"(...) I think that any company should also care about the health of its employees, because if someone feels good, both mentally and physically, then a person can work better and be happier in the company." [E6]</p>
		Benefits of remote work in the mental health	<p>Lack of transit causes less stress</p> <p>"(...) I know that it is something that for a large part that facilitates a lot on the employee side, since I do not have to be stressed with the traffic (...)" [E4]</p>

Category	Sub-category	Code	Quote
		More well-being	<i>"(...) it has a big advantage, since I do not have to go there, I end up waking up later and have a more rested sleep, I am able to eat breakfast with who I live with, and I end up having a more relaxed morning, a lot less stressed, and when I sit to start working I feel more energetic and ready to develop (...)" [E6]</i>
Physical Health	Promotion of physical health	Online exercise classes	<i>"(...) an online physical exercise class, where everyone gathered on Hangouts, with the webcam turned on or not, there were some people who did opt to not do, and we had exercises to do (...)" [E4]</i>
		In person social events outside of lockdowns	<i>"(...) there was a house party that followed the COVID-19 prevention norms (...) we spent two to three days socializing in a house paid by the company (...) and it was also to have a bit of team building, but also to relax and chill." [E3]</i>
		Lack of promotion	<i>"No no, the maximum they did was basically launching a little web page to help people adapting to remote work (...) it was not very helpful (...)" [E6]</i>
Working Hours	Changes in working hours	Motivation for project increases number of working hours	<i>"(...) sometimes I stay a bit longer working because I want to solve a problem and I'm more motivated, for example because it is a project that interests me (...)" [E3]</i>
		Not having separated leisure space from working space increases hours	<i>"More, because I have the laptop near me, (...) a lot of the times I'm laying down on bed, looking at the television, and thinking «I could be using this time to quicken some work» (...) so I grab the laptop and start working, so I end up working more hours." [E9]</i>
		Working hours did not change	<i>"I think that it was more or less the same amount of hours, like I said before, on one hand I would do more hours, but on the other when there was not as much work I would work less hours, so it was more or less the same." [E15]</i>

Category	Sub-category	Code	Quote
		Working hours exemption	<i>"(...) the working schedule always was very flexible, the only thing that holds us to the calendar are meetings and some synchronisation processes, but was always flexible, and still it (...)" [E16]</i>
	Timesheets usage	Timesheets allow perceiving effort	<i>"(...) timesheets help more understanding how much time you spend in each task, and where really is the effort of the team (...)" [E1]</i>
Skills and Technologies	Learn technologies in a pandemic context	Adoption of new technologies in work	<i>"Yes [I had to learn], before we did not use Zoom, and now we do, it is the only difference" [E5]</i>
		Learn new technologies outside of work	<i>"Yes, outside of work I started developing things in Kotlin, which I do not have the necessity to use in the company, I started using Java to relearn and that's it." [E10]</i>
		Did not try to learn new technologies	<i>"Not really, because I do not have a lot of time to do it." [E7]</i>
Productivity	Increase in productivity	Pandemic caused increase of productivity	<i>"It was positive, I was getting annoyed with not being productive enough some days [in the office], and at home I feel much more productive, and I can organize the day more my way, and I feel like I can produce way more (...)" [E16]</i>
		Lack of travels to work affect productivity positively	<i>"I can say for example the fact that I do not have to travel to work and worry about leaving home to do my stuff affected my productivity positively (...)" [E1]</i>
	Impacts on productivity	Children have a huge impact on parents' productivity	<i>"(...) mainly some attention to people with children, how they were dealing with that, because at that time online school was also starting, and depending on the children's age, it can be really stressful (...)" [E8]</i>
	Productivity Evaluation	Indirect evaluation based on added value	<i>"(...) it is done a assessment in the sense of, for example, performance evaluation, but what is measured is the value added, instead of productivity itself (...)" [E3]</i>

Category	Sub-category	Code	Quote
		Yearly evaluations	"Yes, it [productivity] is measured in my company, the performance evaluation that we have are done yearly (...)" [E4]
	Types of online social events	Virtual coffees as social events	"(...) for example sometimes we would each one take some snacks, each person took whatever they wanted to eat, a beer or a cider or whatever, and we would be there chatting like we were at a coffee shop, but each one at their own house(...)" [E10]
Social Events		Events incorporated into meetings	"(...) on our meetings where we analyse what happened during the week, there is a space more dedicated to educational games and things like that, not only to get to know each other in our team, but also to relieve a bit of the pressure (...)" [E3]
		Social events as team building	"(...) there were also some team building events, not long ago a colleague changed to another team and in the farewell moment he organised a team building event (...) so there was a kind of online event where we all shared information about ourselves to create some kind of knowledge between the people of the team." [E14]
	Benefits of social events	Brings people together	"(...) they always help in the sense that there is maybe more contact with people that you cannot have with, at the time you could not be so close of people (...)" [E4]
	Influence of social events on adaptation	Social events helped adapting	"Yes, they helped me understanding more the enterprise context, they helped me having some idea of what was happening in the company, because otherwise I would be much more focused or in my corner doing my work, without knowing the impact of the pandemic on the company, so it helped in that perspective." [E15] " Yes, I think so, essentially they helped not losing connection with people who I already worked with, and since the teams recently changed, there was a lot of new people, and it helped to create some kind of connection that otherwise would be non-existent." [E16]

Category	Sub-category	Code	Quote
Development	Types of development	Agile Development	<i>"They helped me having contact with people, which is something that not everyone needs, but here is a lot of people who need the social factor and feel engaged, which is something hard (...)" [E18]</i>
			<i>"(...) beyond that, on a methodological view point of the organisation of the team, we still are making the same ceremonies, we keep working in scrums, we keep having the same kind of project evaluation meetings, of estimates, of retrospectives, of reviews (...)" [E14]</i>
		Solo Development	<i>"I always worked very much alone, practically alone in my team, so I end up doing all the process, it is all done by me (...)" [E11]</i>
		Development did not change with pandemic	<i>"It did not change much since the pandemic happened, it is still the same things but on another format (...)" [E0]</i>
		Did not observe less privacy	<i>"No, at all, I never had that problem, no one from the company said that they wanted to control what am I or not doing, what I am using, I never had that problem at all." [E6]</i>
Privacy	Tools help keeping privacy		<i>"(...) Teams removes your background, so they cannot even see your room, it looks totally blurred, wherever you are (...)" [E9]</i>
Regulations and Costs	Increase of expenses	Privacy Control	Quote
			<i>"Although I believe that the existing technologies allow to help in the preoccupation that is the privacy when someone is working from home." [E4]</i>
		Control over turning webcam on or off	<i>"No [I do not have less privacy], because I insist on only turning the webcam only when strictly necessary." [E3]</i>
	Reported increase of expenses		<i>"And the electricity also increased a bit because I was at home using my resources, which did not help." [E2]</i>

Category	Sub-category	Code	Quote
		Increases are compensated by transport allowance	<i>“(...) the truth is that the company also gives a transport allowance, and at the moment no one is using it, so one thing ends up compensating the other (...)” [E1]</i>

Table II.1: Summary of the theory's categories.

