FRAMEWORK FOR MINIMIZING THE IMPACT OF UNCERTAINTY IN SOFTWARE PROJECTS DURING COVID 19 PANDEMIC

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Framework For Minimizing the Impact of Challenges in Software Projects During Covid 19 Pandemic

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Candidate of **Master of Science in Software Engineering (MSSE)** at the National University of Modern Languages do hereby declare that the thesis **Framework for Minimizing the Impact of Uncertainty in Software Projects During Covid 19 Pandemic** submitted by me in partial fulfillment of MSSE degree, is my original work, and has not been submitted or published earlier. I also solemnly declare that it shall not, in the future, be submitted by me for obtaining any other degree from this or any other university or institution. I also understand that if evidence of plagiarism is found in my thesis/dissertation at any stage, even after the award of a degree, the work may be canceled and the degree revoked.

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ABSTRACT

Framework For Minimizing the Impact of Challenges in Software Projects During Covid-19 Pandemic

The novel Corona Virus was originated in Wuhan, China, in December 2019 and was declared a global pandemic in March 2020 by the WHO (World Health Organization). Covid-19 has been disastrous; it has influenced every aspect of life around the globe, with a death toll of millions till date. Global pandemic has changed how every human, institution, and organization works. The fatal virus and its spread also targeted the software industry. This research analyzes how the COVID-19 pandemic has affected software projects and some of the challenges faced by the teams. A mixed research methodology has been used, including the systematic literature review. Further, to add empirical proof, information has been gathered from different software houses by conducting an online questionnaire-based survey. One-on-one interviews are also conducted to validate the survey results. The research has identified some of the challenges and proposed valuable mitigation techniques by keeping the local working culture of Pakistan in mind. Based on the gathered information, a conceptual framework has been proposed and initially validated by experts in the respective field.

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DEDICATION

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Uncertain occasions require a quick response to survive; this research would help us understand challenges and navigate it. The uncertain Coronavirus pandemic has entirely changed the structure of every industry and interfered with many elements of our lives, also the IT business [1]. The pandemic, as of now, has reshaped how organizations work; similarly, in software engineering, it has brought changes in the communication methods, strategies, and team work. Different impacts are probably going to be found in the coming years. One of the main changes through which COVID-19 has affected most companies is remote work. This is simply a routine change for organizations that have effectively adopted virtual teams. Still, for other organizations, it will probably have a long-term effect on projects, group efficiency, and joint effort [2].

According to a recent United Nations Conference on Trade and Development report, Pakistan will suffer greatly post-COVID era. Consequently, it has increased the concern about monitoring the effects of the pandemic on the software industry in Pakistan. Further, the worst case will seriously affect the work efficiency of those organizations since they are exceptionally reliant upon the economy, which has been a loss due to the pandemic [3]. Coronavirus and different challenges have taught us that we as a society need to address the following difficulties to guarantee huge loss:

I. Help save the lives of the citizens and paramedics.
II. Help oversee and control the risk factors rapidly.
III. Rebuild and change the affected areas for collective strength [4].

Disasters like Covid 19 require proper plans and solutions to every possible or uncertain situation. There is a need for appropriate web portals, mobile applications, and other technical aids to cater to issues causing any harm to the projects under work. These arrangements should be done for various geographical areas with multiple capabilities and delivered rapidly at a larger scale to meet the requirements in a difficult time. The government sector has the privilege of generating different strategies and rules to help businesses with small-scale projects because it is impossible to develop individual solutions or ideas for problems faced by multiple organizations.

Although there is a change in the behavior and the decision-making of every individual, organization, or institute during pandemic, most services shifted to an online mode. Reliability is now a challenge to meet for small as well as big organizations. Teams used to work remotely, but now they have adopted this agile development technique of working from different geographical locations, making both ends meet. Teams must manage the social distancing that has influenced social interaction, and cross-cultural exchanges, leaving people isolated and alone [5]. Multiple health-related issues were highlighted during this time. There was severe work stress and work-family conflict.

Although the organizations were expecting proper contributions for their benefit, even when work conditions were not so well suited for the employees. The performance and efficiency dropped during this time, as we work better when we work and learn together [6]. The pandemic has affected the software projects in many ways; it has changed the processes, and methodologies. We will see several changes in the coming years. Let’s hope the difference is for good. Organizations wanted to safeguard their workers’ well-being, which is why the physical presence of staff was reduced to 50% of the total [7]. It was challenging to run the same system with half of its workforce present in a day. Teams were not used to working remotely, which was an alarming threat regarding mismanagement.

Some organizations keep paying total wages to their workers well. Some with small-scale projects were not financially stable enough to spend that much. Financial set back was another issue faced during the pandemic [8]. Work integration was a severe issue during COVID-19;

individuals worked from different locations. Gathering all the work and integrating it, following the time constraints, was challenging for project managers. And incorporating it without the combined presence of the overall team is a challenge. Keep track of all the work, follow the time limit, and manage the workforce.

The purpose of the research is to highlight all the unusual risks that have occurred to the software projects across the globe; the study would find out the root causes and the effects of the pandemic on them. How was the situation handled, and what is the possible severity of such uncertain conditions? The digitalization of workplaces was very much in progress after the pandemic [9]. However, the limitations made it impossible to use them all at once. Some companies had to face inconvenience because they were forced into it; they were pushed to opt for specific platforms to work and interact with that they had not previously used.

They had to train the whole staff to keep the work smooth. Regular meetings and gatherings have changed into gatherings on advanced platforms like Zoom, Microsoft Teams, and Google Meet [10]. It got more complex to achieve the goals, especially the collaborative work and tasks. Meetings with the customers and regular follow-ups were not possible during COVID. But there was an obvious result of better work, too; some reports show that the code improved during work from home. Virtual learning opened gates for many people. People learned and shared knowledge with their teams over the internet.

And especially those teams who used to work remotely even before the pandemic were not affected in any way. They were familiar with rules, platforms, and interaction techniques for meetings and collaborations [11]. It is essential to have people who can work as a team and make critical analysis. Because cooperation is the real key to success. And the plan is well executed if the team is mature enough to work well on it. They have a sense of facing difficult times and plan to sail through them.

1.2 Literature Review

COVID-19 in Pakistan was first reported on February 26, 2020, and the number of positive cases started rising quickly because of traveling across the country. The cases increased after the declaration of lockdown in Pakistan, and the situation worsened [12]. The adverse effect of COVID-19 on software projects has been seen without exception, but the density of the impact has shifted across areas, sub-areas, business types, and firm sizes. However, the research says that the least affected area is agriculture. On the government's order for the lockdown, many industries got shut down, which had a significant effect, with a great number of the firms reported to have been directly affected by the lockdown.

Covid-19 has brought so much change in the workplace for every organization in Pakistan. Because of the lockdown, every organization has been working remotely over the internet, calling it to work from home. Even though remote work in the software industry was already a term and people used to do it even before Covid-19, it has been a significant change for everyone. The software industry has been chosen for this research to see what it has been through [13].

Research has observed and analyzed the effect of the Coronavirus pandemic on software projects and the teams [14] by covering different aspects like their health, work efficiency during the pandemic, fulfillment level from what they do, how are they maintaining uncertain differences in their daily life and in response to such surveys some team members were happy with ignoring the difference in work. In contrast, the other group wasn't pleased with work from home and other uncertain differences during the COVID days. So, it is evident from the research that most organizations didn't welcome the change, but for a few, it was normal to work remotely as distributed teams.

The research has identified different uncertain issues reported during the global pandemic by people from other software-developing organizations. These issues are highlighted to get the initial solutions for them. Some problems were feeling disconnected and isolated, financial hardships, decreased work efficiency and progress, and an unhealthy work-life balance [15]. So many people lost their jobs. It was hard to manage recruits in a remote environment because of the pressure to meet the requirements of geographical differences. Some have reported nervousness,

Unsatisfactory home environment for remote working (for example, no space, an excessive number of individuals in the house). Some have reported worries about living arrangements [16].

The present circumstances require a proper plan by the government that involves the essential financial and social betterment of every individual of the country; the planning should cover multiple aspects of the affected areas from the COVID-19, with defined strategies to proficiently and adequately minimize, mitigate and monitor the unfavorable impacts of the pandemic. This also refers to mobilizing financial and technical needs of organizations with smaller businesses.

A combined effort of the government and the UN office has helped make a report on the socio-financial impact and a response plan [17]. The plan is about a proactive response to an uncertain situation and dealing with the medium to large-scale effects of the pandemic. It carries the policies to be implemented at an institutional and an administrative level.

The research tells how software projects and software development teams have been affected by the prevailing circumstances of Covid-19 [18]. How has their work changed from before Covid-19, and if there have been any limitations with the switch to work from home, or has it been no problem adapting to these circumstances? It has also focused on how the companies and project groups using remote software development intentions after Covid-19 are.

Suppose the companies plan to stay on course the way they have done the past year or get back to how things were set up before the pandemic. Research has shown how Covid-19 has affected people working from home with remote software development teams [19]. To see the differences between before and during Covid-19 in software houses covering small-scale projects? From the companies that are investigated, what will be the future going forward with new plans? Consequently, these are the questions that the study aims to answer in this research to get more information about this area. One primary consideration in this research is ethics because numerous individuals from different companies will be asked several questions in the survey and the questionnaire. Four other research ethic principles will be followed in this study: the information

requirement, the consent requirement, the confidential requirement, and the utilization requirement.

Strict and early guidelines and policies are needed to cater to the aftermath of the corona pandemic. To save lives and protect the weak and underdeveloped communities from balancing the unstable economies. The health issues across the globe are worst; the health care system is declined to its worst in the last decade [20]. World Health Organization has given it the name of a global pandemic attacking every community worldwide. The economy went down to 1 percent in 2020, and a severe threat of further shrink is expected to ruin economic activities.

The wide spread of the global pandemic has paralyzed the global economy on a larger scale. It has caused unemployment in most countries. But we have seen the significant effects in those underdeveloped countries with weakened economies and high debts to pay. Compared to big economies like the US, Europe, and China, they have seen minor damage since they were already stable. Smaller economies are struggling to meet the required health care system; they are trying to provide the needed health facilities to their people. Underdeveloped economies are in no place to pay back their debts and progress as they were doing before. They are hardly meeting urgent emergencies. The world has not faced any big financial crisis like this in the last 100 years.

The spread of the virus has increased the death toll globally; we can see hundreds of deaths every day. It is a big challenging moment to understand its severity to take maximum and urgent steps to adapt to the oddly growing situation across the borders. It has taken several lives by now, and the problem is not in control. Socially distant societies face social crises and economic setbacks. There is a spread of anxiety and stress among the people after seeing the declining financial situation in their respective countries [21]. The global process of manufacturing and supply has gone down to the lowest level dramatically. It will probably take a hundred years to overcome this loss for many economies. And the loss is significant to be compensated.

Fall in the Global GDP, crises like financial, career, and health-related were reported in a more significant number during the pandemic. Delays in the production and shipment processes affected the overall business leaving companies in debt globally.

These issues need serious cooperation from the world, small developing countries, and in real need of proper planning post-pandemic to overcome the loss in every area. We can see some positive outcomes if the more extensive community helps, the smaller, but we have seen its effects even on the stronger communities like Europe and northern America. The rise in death toll and the need for health care has made it difficult for every country regardless of its economic stability. The pandemic has undoubtedly shaken the global economy by leaving no place unaffected. It has affected the supply chain, international trading, tourism, traveling, and exports. 100s of countries shut their borders to implement strict actions against traveling and trade. Millions of people lost their jobs during this challenging time.

It is too early to conclude the overall damage that the spread of COVID 19 has caused; according to global economists, it is going to have long-term effects on the world's economy, and the estimated downfall in the rate of GDP has dropped from 3.0 percent to 2.4 percent in 2020, which is more than the estimated rate. Countries not developed would most likely face the hard-hit as compared to those with a stronger GDP. To look into a broader perspective, the general global GDP was around 86.6 trillion dollars for 2019; it showed only a 0.4% decrease in the overall economy, but the report was given before the virus became a global pandemic. We get to see strict lockdowns and no social contacts. We have seen a dramatic change in the worldwide stock market, causing a severe downfall after the wide spread of the virus.

1.3 Problem Statement

The software industry has also faced so many challenges due to the COVID 19 pandemic [22] especially the software industry in Pakistan; most of them are handling small-scale projects with a particular budget, time frame, team members, and other factors involved, such organizations are bound in most of the cases, and they are not always well prepared for any such challenges [23] So, to address an issue like this, the following research aims to understand and identify the possible

challenges[24] with the high risk involved. The proposed framework can handle future inconvenience with the help of mitigation techniques stated in this research.

1.4 Research Questions and Objectives

RQ1: *What challenges were faced in software projects during COVID-19?*

RQ2: *How the proposed framework can cope with the identified challenges?*

1.4.1 Objectives

RO1: To identify the effects of Covid 19 pandemic on software projects.

RO2: To develop a solution for any future challenges like COVID-19.

1.5 Methodology

The research has been conducted following a mixed method approach [25]. The descriptive data has been gathered through existing literature, for statistical data an online survey has been conducted. For the validation of the survey results a qualitative approach was adopted as interviews. Following sections are going to explain the steps in detail.

1.5.1 Existing Literature

The available reports, research papers, and the existing literature has been studied to investigate and understand the proposed topic and its domain. It was the primary source for the gathering of facts about the subject.

1.5.2 Online Questionnaire

An online survey has been conducted using a questionnaire to collect statistical and factual data from a more significant number of individuals working in different software houses in Pakistan. This aim was to gather unbiased data from different organizations [26].

1.5.3 Interviews

Once the baseline understanding was done, one-on-one interviews were conducted with the prominent members from the various software houses to validate the survey results, and gather authentic information required to complete the research with the qualitative analysis [27].

1.5.4 Development of a framework

The most important part of the research was to develop a conceptual framework that could help in coping with the effects of pandemic on software projects or for any such future challenges [28]. Framework was developed with the help of mitigation suggestions gathered by interviewing the experts in field and the developed framework has been thoroughly discussed in chapter 5.

1.6 Scope of Study

The targeted area of the research was the software industry and the effects of global pandemic on the ongoing software development projects, to identify the effects, the results have undergone a process of analysis w.r.t the Pakistani software industry culture.

1.7 Contribution and Significance

If this research is added to the literature, it can contribute in helping project managers and the teams to cope with future challenges:

If the software industry learns to cope with these challenges, it can manage economic growth well, and innovative ideas can improve customer efficiency and production. The research influences the social aspects of the Pakistani software industry. If the software industry plans well for any misfortune, people would not lose their jobs, or it would not affect their earnings much.

Physical and social distances would be managed well by keeping a community together.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In 2019 the world witnessed the massive spread of a virus which infected over 382 million people globally. It resulted in more than 6.7 million deaths (as of February 2023 by the World Health Organization) [29]. COVID-19 originated in Wuhan, China, in December 2019 and was declared a global pandemic in March 2020 by the WHO (World Health Organization) [30]. The pandemic shattered the global economies with the massive increase in active cases and the death rate with each passing day. No country, life, or power stayed untouched by the brutal virus. Covid 19 has been disastrous. Its impact on organizations and people worldwide has been enormous.

The impact has been different across the globe. The pandemic has caused unprecedented financial and economic disruptions. The Covid 19 related challenges negatively impacts returns on all sorts of industries. Some industries are more resilient than others and are not primarily affected by it. The pandemic has significantly disrupted some of our current ways of working in different organizations [31]. We are struggling with the short-term challenges of work sustainability, employee well-being, and productivity. It is now a challenge to think about how we can work together to transform the organization for a different future.

Following the onset of the global pandemic and subsequent lockdowns in various parts of the world, the software industry was disrupted and abruptly forced into new ways of working. The working environment dramatically changed during the course. Various changes deeply impacted typical working routines, affecting both productivity and well-being will be long-lasting effects of pandemics on the software industry. Hence it is crucial to decide how a typical working day looks when working from home and how the individual activities affect teamwork [32].

An organization as big as Microsoft was the first one to ask its employees to work from home. Several studies were conducted to register the global experiences of working from home, especially in the software industry [33]. Mixed results were found, with challenges like virtual meetings, overwork due to limited resources, and some initial mismanagement in remote teams. Some nonprofit organizations could not bear the financial crisis burden resulting in the firing of many employees, leaving them unemployed in between a destructive global pandemic [34].

Although some employees were happy working remotely as it was flexible to move to their families in times of significant loss, the pay cut movement created tension between skilled workers who were enjoying a considerable amount of money by working in bigger cities. Companies from Silicon Valley were making drastic changes [35], including pay cuts of up to 15% depending on where an employee moves. The difference could devastate current and future remote hires in various cheap cities who might receive a lower wage.

The software industry depends on large teams collaborating and communicating at each development step. Long before COVID, the software industry was familiar with the concept of geographically distant team members. The pandemic, however, has changed the team working culture and productivity [36]. Developers could not reach the milestones, and the factors involved were ineffective communication and lost social connection. The development team realizes that daily social interaction is necessary for collective brainstorming with the team members to achieve maximum work production.

Scrum is one of the famous models in software development, teams feel organized and well-informed following it, but COVID-19 has made it difficult for some teams to follow remotely. The remote video conferencing and asynchronous communication caused an overhead never experienced before by organizations that never had worked in remote scrum culture [37]. We have seen that agile development was the only way, but many organizations were not trained to work in such an environment. Several scrum variants were created and launched to experience new ways of handling large projects to accommodate small groups. Still, results were never so good because of the lack of validation of the adopted approach.

Agile software development focuses on iterative and collaborative work [38]. The team members own code ownership, and regular meetings and collaborative practices are observed in agile teams working on the models like scrum and XP. This was highly affected due to the work-from-home initiatives taken by almost every organization during the pandemic [39]. Something like pair programming wasn't possible in times of social distancing because not every organization was ready to reorganize its current working model. Whereas immediate coordination needs were fulfilled via communication tools like Zoom, Teams, and Google Meet. The fully distributed work setup was problematic for teams accustomed to exchanging work on-site.

Long before the pandemic, most organizations were not working on a distributed level, there was no concept of working from home, and not all the organizations had a set up to access the servers from anywhere but only from the offices. For that reason, their technical infrastructure was not sound. It was even reported that online mediums were not safe. And companies were not prepared to shift their small or large setup for unsafe remote work [40]. It was unexpected for them to distribute their resources equally to the geographically distant team members by setting up a new infrastructure that required technical and financial investments.

The absence of an internal end-user was a problem in getting regular feedback on different modular projects, resulting in various repetitive changes to the work. Even the process of testing was limited to automation. There was no way to evaluate the prototypes in real-life settings. These challenges increased the team's workload and resulted in dissatisfaction at both ends of the workers and the customers. There was a severe loss of information while communicating via emails, or calls, which often confused the different team members waiting for an order or a request to work or rework [41].

In addition to all these problems, many workers lost their jobs during the pandemic; companies were in debt to pay their employees further, pushing them to struggle to make online clients around the globe freelance and work to earn a living. Some skilled workers were lucky enough to find work now and then, but the work schedule in the online labor market is 24/7 across all time zones and spatial borders. There is no work discipline for freelancers; they have to work

at all odd hours, even on weekends, to meet the differences in time zones and the given deadlines [42].

Aligning expectations with the clients was one of the challenges for the software industry in times of COVID-19. Their responsibility was to continue delivering value through cycles, keeping the employee's welfare in mind [43]. The organizations couldn't lose any of them, both the clients and the workers. However, several organizations lost their key workers and old assets while struggling with the financial crisis. Initial mismanagement caused mistrust resulting in the loss of clients. So, the pandemic was about companies' global loss [44].

2.2 Systematic Literature Review

2.2.1 Identification of the Research Question

RQ1: *What challenges were faced in software projects during COVID-19?*

The systematic literature review has been conducted using kitchenham guidelines, from 2019- 2022; various digital libraries are utilized in search of the papers, including Elsevier, Springer, IEEE, Google Scholar, and Wiley. The purpose of research on the topic was self-evident; it is essential to learn more about the challenges faced by different global teams during and post COVID19 [48]. A thorough study is required to highlight the overall impact of an uncertain situation on the software industry. The analysis would help the researchers and practitioners understand how important it is to have some proactive plans for future challenges and recover from the already faced loss.

2.2.2 Inclusion-Exclusion Protocol

Table 2.1: Inclusion-Exclusion Protocol

Criteria	Include	Exclude
Date	Papers were taken from 2019 till 2022	Documents before 2019 were excluded.
Topic	All the papers explaining the software industry's different challenges were included. Papers explaining how the software industry changed during the global pandemic were included.	Papers irrelevant to the research question were excluded.
Type of Study	Papers in the English language are included only. Papers properly published are included.	Papers irrelevant or not covering the required knowledge on the topic are excluded. Papers not in the English language are excluded.
Number of papers	37	43

2.2.3 Research Conduction

The initial search is done based on a search string that is relevant in a way that covers almost every aspect of the study, including uncertainty, challenges, the software industry, and the software development teams. Kitchenham guidelines are being used in developing this string.

A. *RQ1: What challenges were faced in software projects during COVID-19?*

Population: Software Projects

Intervention: Challenges during and post Covid-19

Comparison: Comparison between Pre Covid and during Covid

Outcome: Identification of Challenges or uncertainties.

1. **Search String:**

   "Challenges" AND "Challenges in COVID-19" AND "Software Industry in COVID-19" AND "Analysis of Challenges" AND "Analysis of Software Development Teams" AND "Challenges in Software Projects" AND "Challenges faced in software Projects" AND "Challenges faced by Software Teams".

Table 2.2: Initial Search String

Data Sources	**Search Strings**	**Number of papers**
IEEE	"Challenges" AND "Challenges in COVID-19" AND "Software Industry in COVID-19" AND "Analysis of Challenges" AND "Analysis of Software Development Teams" AND "Challenges in Software Projects" AND	10
Springer		30

	"Challenges faced in software Projects" AND "Challenges faced by Software Teams".	
Elsevier		5
Wiley		5
Google Scholar		30

2.3 Data Extraction

Data were extracted from the 37 primary studies following a predefined data extraction form. The form has helped us record the details of the papers under review and the specific results to support our research questions. The predefined data extraction form is added in **Appendix B**.

2.3.1 Primary Studies

Table 2.3 shows some of the studies that have been reported in relevance to our research questions. The Table consists of 3 columns, the first column for the author's name, the second for the year of publication, and the third column shows the paper's title.

Table 2.3: List of Some of the Studies

S/No	Author Name	Year of Publication	Title
1	Afrianty, T. W.	2022	I am working from home on effectiveness during Covid-19: Evidence from university staff in Indonesia.
2	Miller, C.	2021	" How was your weekend?" software development teams were working from home during covid-19.
3	Griffin, L.	2021	Implementing lean principles in the scrum to adapt to remote work in a Covid-19 impacted software team
4	Azizi, M. R.	2021	Innovative human resource management strategies during the COVID-19 pandemic
5	Russo, D.	2021	The daily life of software engineers during the covid-19 pandemic
6	Nolan, A., White	2021	To work from home (WFH) or not to work from home? Lessons learned by software engineers during the COVID-19 pandemic
7	Dunn, M.	2020	When motivation becomes desperation: Online freelancing during the COVID-19 pandemic.
8	Chawla, A.	2020	Coronavirus (Covid-19)– ‘zoom’ application boon or bane

9	Morens, D.	2020	The origin of COVID-19 and why it matters
10	Sohrabi, C.	2020	A review of the 2019 novel coronavirus (COVID-19).
11	Weil, T.	2020	IT risk and resilience—Cybersecurity response to COVID-19
12	Crayne, M. P.	2020	The traumatic impact of job loss and job search in the aftermath of COVID-19
13	GonzÁlez, R. J.	2020	Life under lockdown: notes on covid-19 in Silicon Valley
14	Kaushik, M.	2019	Employee relations and engagement during covid-19

2.4 Data Synthesis

The extracted research has covered the study from the birth of Covid 19 and its global spread [49]. The study's strength is the background history of the COVID-19 pandemics listed clearly by the author. Covid-19 was a massive outbreak [50], affecting the software community. The study has explained the drastic effects of COVID on agile development across the globe. Agile software development is famous and the most commonly used process. But the virus has changed almost everything about agile development, and nobody can escape its effects [51]. The research has stated a fascinating idea about risk intelligence and how innovation is taking place to plan the risk and uncertain future proactively. Those with healthy working environments faced more secondary consequences; their resilience saved them from significant losses. So, the importance of risk intelligence is as vital as anything [52]. Most of the literature shows the changed lifestyle after

the COVID19 pandemic; and how the development process has been changed globally for all software projects. A change to this extent was never seen before.

Table 2.4: Different Perspectives on Post COVID-19

Percentage/ Ratio	**Perspectives**
90%	Believe that the COVID-19 crisis will fundamentally change how they work over the next five years.
85%	They are concerned that the COVID-19 Crisis will have a more prolonged effect on their customers over the next five years.
21%	Have the expertise, resources, and commitment to peruse new growth quite successfully
2/3	Believe that this is going to be the most challenging moment of their executive career.

It was not welcomed anywhere in the world. Instead, it only caused suffering. The world has witnessed changes in managerial duties in the software industry [53]. Software development is very much dependent on software project managers. But the traditional organizational techniques were of no use during COVID-19. Software project management had to adapt to a new level of project management and development.

Different ways have been adopted to sustain small and medium-level enterprises and how they have been maintained and transformed as per the need in COVID-19 [54]. Also, how Microsoft took a leap of faith to start working from home with a new working routine, and then the smaller companies dared to follow in their footsteps. The study shows the overall disturbance due to the COVID-19 pandemic. The distributed teams had to face a lack of communication, and the most significant loss in COVID19 was the loss of jobs and pay packages. The study explains the various policies that came into existence for payment methods and salary cut-offs. And how skilled and settled people were not satisfied with their earnings during this time. Although the software industry was already familiar with remote teams, some organizations were already working on the concept of geographically distant team members [55]. Yet, it was a new thing for most of them to set up a whole new system to get into a routine. It was a different path to manage and took time to establish. The research had stated a significant output faced during COVID19; it was seen that unemployment took place during this era at a mass level, leaving less or no opportunities for people to earn and sustain themselves in those more challenging times [56]. The study also covers the differences in time zones for employees and the hardships along with them.

The study explains how the agile development process could help fight the issues caused by COVID-19. The study shows larger companies working on agile and how they are team-dependent. A collaborative effort is required for the teams to work in an elegant system with regular meetings and iterative sessions. The study demonstrates that it was challenging for the Masters to handle scrum in a new way as they used to do in earlier days [57]. The study further explains how the issues were evident for countries facing a drop in GDP. The study says that the financial losses were drastic for the world [58]. The research has highlighted challenges regarding no planned infrastructure to shift to a digitalized mode. Organizations could not easily digitalize their whole working culture [59]. And a key factor highlighted is the lack of financial assets to adapt to technology. The study has also covered an essential aspect regarding the digitalization and data integration techniques followed by the banks and financial management institutes in collaboration with the software industry during the global pandemic. The benefits of digitalizing are endless; Pakistan decided to shift to a digitalized voting process in future elections [60]. Moreover, the study has shown how life was changed for individuals both mentally and physically. How the work from home has positively and negatively affected the overall productivity and performance of the

employees. And how health and psychological well-being has been the top priority of every organization [61].

2.5 Results

The COVID-19 virus and its spread have resulted in challenges that has changed every aspect of life around the globe. In this study, we have done a comprehensive analysis of the impact of COVID-19 on how the software industry works, using the knowledge extracted from the help of a large number of research papers. The result indicates that COVID-19-related challenges has negatively impacted the global sector, affecting the way organizations work and the overall GDP of the countries [62]. We interpret these results as challenges faced by the software industry in Pakistan and almost every country. Some specific sectors have shown resilience against how COVID influenced the work style. At the same time, most of the industry was unprepared for such change. There have been no proactive plans for the challenges this time. Some organizations had to start from scratch to build an adaptive infrastructure to support their work in remote workplaces with dispersed employees and teams.

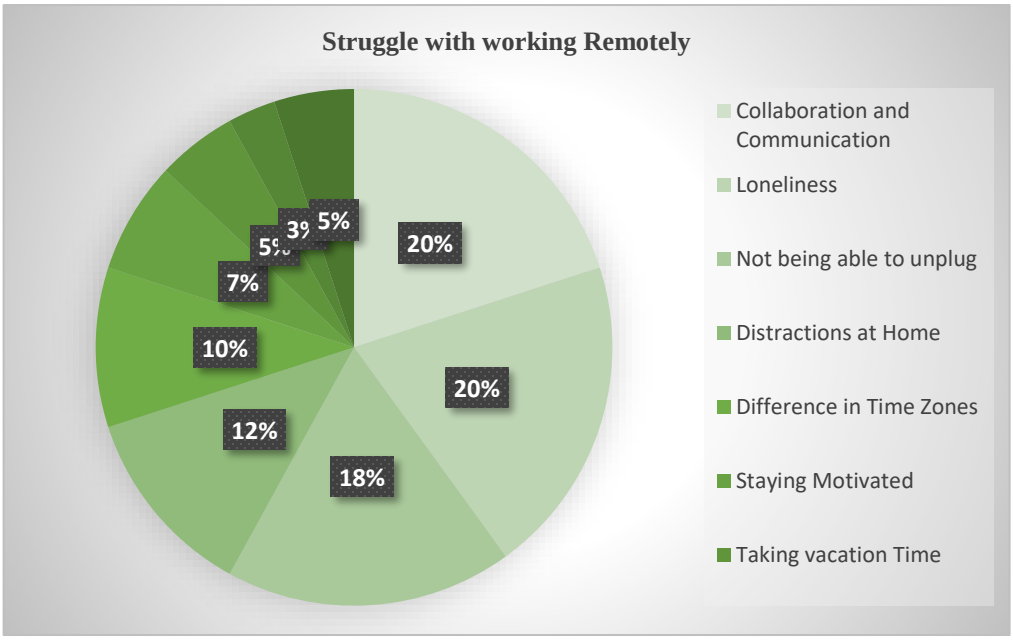

Figure 2.1: State of Work from Home

First, health has been a serious concern for everyone during this time. Strict social distancing and quarantine protocols were enforced to ensure the employee's health and wellbeing. Yet a large community got affected by the virus, and its spread resulted in significant illnesses leading to a reasonable rate. Various lockdowns [63] resulted in closed offices and later with 50% of employees on-site and primarily working in a work-from-home environment.

The management was challenging for the leads to carry the dispersed teams along. With virtual meetings and no daily face-to-face interactions, communication has been a severe challenge. It was a tough call to equally divide the resources amongst every employee geographically distant from another. This set massive in pay and job loss has been observed. No industry has faced this much unemployment in decades. And even those lucky enough to save their jobs were not as productive as they used to be. Companies had to face a lot of customer dissatisfaction resulting in distressed employees.

In times of half-staff at work, the work burden was double on the attendants causing psychological instability between the teams [64]. Due to the lack of frequent feedback from the user end, many reworks and changes were encountered, affecting the schedule and the budget for minor or large software projects. Financial crises have been one of the top challenges organizations had to face during the global pandemic. It was frustrating for the organization, which had not worked remotely before the pandemic, compared to those familiar with the remote working techniques. Change is essential, and change is inevitable for all ages. Those who stay on older routines, conservative in adapting to the trends of technology and research, would always find problems in times of uncertainty, big or small.

The software industry in every country has a significant role in the overall GPD, as this is one vital revenue-generating sector for any state. Organizations need proactive planning for all sorts of uncertain situations [65].

Table 2.5: List of challenges identified from the SLR

S/no	List of Identified challenges	References
1	Lack of Productivity	[31], [32]
2	Financial Instability	[34], [35]
3	Pay cut	[35]
4	Remote Culture causing work Delays	[36], [37]
5	Miscommunication	[39], [40], [41]
6	Job Loss	[42], [44]
7	Declining Health (Mental/Physical)	[43], [63], [64]
8	Lack of proactive planning	[65]

2.6 Conclusion

It is required to monitor the negligence of the current situation of how the software industry has changed after COVID-19. The various challenges are being highlighted and mentioned to be taken seriously. Every organization, big or small, is responsible for thoroughly checking up on the changes and the consequences and planning accordingly. There is a need for immediate implementation of strict guidelines. More prominent organizations with better plans must share success stories and lessons for smaller or underdeveloped organizations to fight future uncertainties. A collective effort is demanded to overcome the loss

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Several approaches can be used for designing the research methodology [70]. In this chapter, we have introduced the research methodology with mixed techniques. Multiple techniques have helped us come across the research results and findings. The chapter covers an overview of the research methods used to collect data. The first part discusses the quantitative approach, which was a survey.

The second part covers the qualitative research method: the interviews. The second part has helped in validating the results collected from the survey. Research methodology is guidance for systematically conducting the research. The methodology helps formulate the study's problem, objectives, and results. The chapter outlines the research design, methodology, study area, population and sample size, quantitative analysis content validity, and qualitative analysis content validity.

3.2 Research Design

The research designs provide an appropriate framework for a research study. A critical decision in the research design process is to choose suitable approaches for collecting data. Table 3.1 shows each research question with its methodology and the targeted results. These questions will address some critical aspects of the software industry influenced by the pandemic. The methods used in gathering data for each of them and the results derived.

Table 3.1: The Operational Framework for Methodology

ID	Research Question	Methodology	Outcome
RQ1	*What challenges were faced in software projects during COVID-19?*	*SLR/Survey Questionnaire*	Identification of challenges faced in software projects during the global pandemic.
RQ2	*How the proposed framework can cope with the identified challenges?*	Interview	Collecting mitigation techniques to develop a conceptual framework.

3.3 Research Methodology

A methodology is a process or structure of guidelines or principles. It may say directions from which the exact and specific procedures or methods may be imitative to understand, solve, and change the difficulties [71] within the defined scope of a discipline. The core point is to get desired or required outputs based on that final finding or results. To address these key objectives, qualitative and quantitative techniques will be used. The qualitative data would help in validating the quantitative data analysis and results. So, the results would be triangulated using qualitative and quantitative techniques.

3.3.1 Study Area

The population means the comprehensive set of (subjects or events) having similar characteristics in which the research is being conducted. The population of the study is done through random sampling with the help of different colleagues working in various software companies across Pakistan. The data collection process is done from July 2022- August 2022 different software houses and IT companies in Pakistan **(Appendix E).** The software industry faced a hard fit due to the worldwide pandemic, and so did the Pakistani software industry. The overall lifestyle has changed over time and influenced the economy [72]. Keeping the objectives in mind, the industries were selected based on their ability to meet the required criterion.

3.4 Data Source

3.4.1 Survey

Surveys are done when you have to analyze a comparative audience. Surveys have an extensive capability to gather a more significant sample to meet the targeted results. No other research methodology can cover a larger population as surveys do; a more substantial sample helps get more authentic results to analyze. Surveys are based on practice, attitudes, and knowledge [73]. We have performed a survey (**see Appendix A**) to find the challenges faced by the software industry during the global pandemic and how they may affect the industry's work. A structured questionnaire is developed [74] with the help of peers. The questionnaire consists of 14 questions later validated through one-on-one interviews. This would further help in making a base for developing a framework as a solution to the identified and analyzed issues. Following are the steps of the survey.

3.4.2 Survey Steps

The survey protocol is comprised of seven steps. Simple random sampling has been done for the survey population. As the focus area is the uncertain factors faced by the software industry so the first step would help in identifying all the challenges caused by the global pandemic for the software industry. For the second step, we need to identify the target audience directly or indirectly affected by the hit. It is going to be various software houses working on all sorts of projects, big or

small. In the 3rd step, we will identify the people representing our research's target audience. Project managers specific and some of the other team members of a software organization, like requirement engineers, analysts, developers, coders, testers, QA, and analysts, can serve as the representatives of the target audience in our case. Step four is a crucial baseline of the research survey. It is an essential and challenging procedure to develop a questionnaire that is sound, output-oriented, suitable, structured, and well within the boundary of the domain. Step five is comparatively attractive, as we would allow the target audience to come forward and help analyze the overall credibility of the questionnaire. Anything that was skipped while making a survey questionnaire would be added with the help of those who have witnessed the issues themselves. Their valuable feedback would help improve the questions resulting in a better collection of facts and figures. In step six, a well-structured questionnaire would be distributed among the representatives of the target audience who would be stating the information for our research. In the final step, gathering and analyzing the information or data from the questionnaires is essential. The analysis would help us develop a report listing all possible factors and the reasons.

I. Identify Research Objectives

Our main objective is to list all the factors, challenges, and difficulties the software industry had to undergo during and post COVID19. The global pandemic has undoubtedly affected every aspect of human life, including the IT industry. To help understand the issues and avoid them in the future, it is essential to identify them first. This would allow the software project managers and those responsible for running different projects in software houses.

II. Identify and Characterize the Targeted Audience

It is the base for a survey to properly understand the audience directly or indirectly linked to the stated problem. So always start with your potential audience in mind [75]. Only those can help identify issues and can be facilitated by a solution. It is useless to research if it has no benefit for those who are the targeted audience. And remember, and rightly analyzing the audience is one of the most critical steps in the survey.

III. Design Sampling Plan

We can't take responses from all those linked to or affected by a specific problem. There is always a sampling procedure to pick the best suitable individuals who would represent a larger community by putting forward the information that is valuable for those needing it and those who are related to it. So, suppose we are considering the software industry as the boundary of our research. In that case, we can pick some well-informed software project managers to help us generate our questionnaire.

IV. Design Questionnaire

It is essential to develop a well-structured questionnaire that would help in collecting the best form of facts required to answer the research questions. Questions are the only credible source to communicate with the respondents and are a window for the overall research. Their answers would only be sound if the questions were developed under peers' proper supervision and guidance. (**Appendix F)**

V. Pilot Test Questionnaire

Pilot testing is all about getting your initial draft of the questionnaire to be checked by your peers. **Appendix C** form was designed to test each question and take expert review on a scale of (1-4). This has not only helped improve the questionnaire but to make it rich and as per the objectives. After that, the questionnaire is confirmed to be distributed.

VI. Distribute Questionnaire

Now that the final questionnaire is ready, it will further be distributed among the selected audience or respondents. This step is to start collecting the information required for the research to be successfully conducted.

VII. Analyze Results and Write Report

The final step is receiving the questionnaire responses from the target audience. Collecting data is crucial, but analyzing and generating the desired results later is another difficult step. That is the final step before concluding a report about the survey and its success.

3.5 Population and Sample Size

The data population is from the private sector software houses and IT companies in Pakistan. Data has been collected during a survey.

3.6 Content Validity by Qualitative Analysis

3.6.1 Interview

Interviews are recorded **(Appendix D)** on various open or closed-ended questions designed by the researcher and later validated by a peer. Interviews help better understand and clearly explain different research subjects in collecting expressions and opinions for qualitative analysis [76]. There are three different types of interviews. They are structured, Unstructured, and Semi-structured.

3.6.2 Structured Interview

Structured interviews are rigid as they follow the set protocol. But they benefit when you have an extensive list of questions. Structured interviews target specific topics that help gather correct information from a mass population to represent a group of people. Structured interviews don’t need follow-up interviews for improvement. We have followed a structured interview in this

research to validate the survey questionnaire. The reason for using structured interviews for the following research is the validity and reliability of the method [77].

3.7 Chapter Summary

In this chapter, we have discussed the work outline and the survey strategy. An overall view of the survey methodology has been discussed in chapter three. Our study is going to address two research questions. We need a similar survey methodology for both of them to generate the results. In an operational framework, research is planned from start to end. Research is categorized into different phases; every phase must cover essential tasks with valuable results. To conduct the survey, seven different stages and some functions attached to each one are planned for data collection.

CHAPTER 4

ANALYSIS AND RESULTS

4.1 Introduction

In chapter three, we planned a strategy to design a research methodology for collecting data. Data collection has been a long process, divided into two major parts. According to our research methodology, half of our data collection was based on a quantitative survey, and the other half was qualitative interviews.

The second half was to validate the first one. After conducting a survey and the interviews, the data is collected for further analysis and evaluation. The survey was conducted through an online questionnaire, and the interviews were conducted one-on-one. Around 200 responses were recorded in a span of one month. And five interviews were recorded to fetch helpful information.

In chapter four, we will report the results collected through the research. According to our problem statement, we have to collect the challenges faced during covid, their effect, and the solutions required to cope with any such risks in the future. The chapter is outlined as findings that satisfy the problem statement, the research questions, and the results that can help with the hypothesis testing.

4.2 Survey Results

A comprehensive survey was conducted from different roles in software development teams. The survey was conducted online using google forms. Around 200 respondents responded to the survey. A set of questions were asked for demographic information about each one of the respondents.

A 3-point Likert scale was used for frequency, Agreement, Intensity, and Extent. The items were as follows: “High,” “Low,” and “Medium.” And “To great Extent,” “Very little,” “Not at All.” And “Always,” Usually,” “Never,” And “Very Frequently,” “Occasionally,” “Never,” And “Very Often,” “Sometimes,” “Never.” And “Strongly Agree,” “Neutral,” “Strongly Disagree,” And “Extremely,” “Moderate,” Not at All”

4.2.1 Respondents Profile

The online survey is filled by different roles in a software development team, like requirement engineers, developers, testers, QA Analysts, and Project Managers. A few demographic questions were asked to get the essential information from the individuals who participated in the survey. Figure 4.1 shows the percentage of work experience in software development teams by the survey participants.

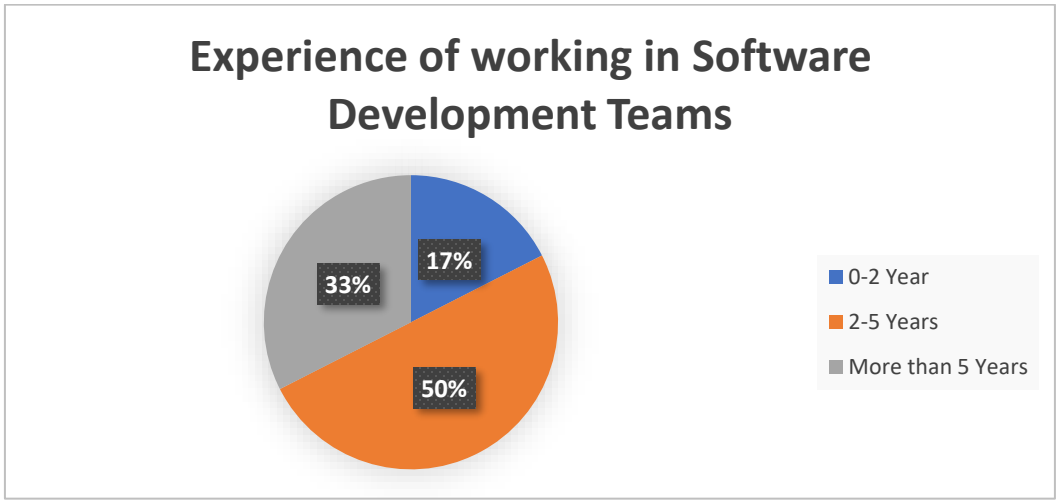

Figure 4.1: Demographic Information of Respondents

The survey questionnaire has covered almost every aspect of the challenging side covid 19 has caused for the software industry, specifically the software development teams. Results are

further analyzed to accept or reject the challenges identified. Table 4.1 shows the result of responses to each challenge.

Table 4.1: Results from responses through survey

S/no	Challenges	Extreme (2)	Neutral (1)	Never (0)	Total 200
1	Difficulty in Requirement's Gathering	216*2= 432	70*1= 70	37*0=0	502
2	Mismanagement in Project Planning	84*2= 168	138*1= 138	20*0=0	306
3	Weak Performance	154*2= 308	90*1= 90	33*0=0	398
4	Drop in Work Quality	54*2= 108	117*1= 117	53*0=0	225
5	Economic Pressure	74*2= 148	129*1= 129	32*0=0	277
6	Miscommunication	164*2= 328	70*1= 70	46*0=0	398
7	Infrastructural lacking	68*2= 136	97*1= 97	66*0=0	133
8	Pay Cut	46*2= 92	55*1=55	118*0=0	147
9	No predefined SOPs/ Framework	234*2= 468	71*1=71	9*0=0	539
10	Employee Loss	52*2= 104	57*1=57	115*0=0	161
11	Product Deployment Issues	32*2= 64	133*1=133	0*0=0	197
12	Scope Creep	34*2= 68	153*1=153	30*0=0	221

4.2.2 Results from Weightage Values

Weightage values are the values that discuss the average response collected against every challenge. The values are pretty significant as they play a part in accepting and rejecting the challenges. The average weightage value for each challenge is calculated using the mean formula.

The average weightage response= Weightage value/ Total No of responses

Table 4.2 shows the average weightage response for each challenge and the results, such as accepted and rejected.

Table 4.2: Result for Accepted and Rejected Challenges

No	Challenges	Weightage Value	Avg. Weightage Responses	Result
1	Difficulty in Requirement's Gathering	502	502/200= 2.5	Accepted
2	Mismanagement in Project Planning	306	306/200= 1.5	Accepted
3	Weak Performance	398	398/200= 1.9	Accepted
4	Drop in Work Quality	225	225/200= 1.1	Accepted
5	Economic Pressure	277	277/200= 1.4	Accepted
6	Miscommunication	398	398/200= 1.9	Accepted
7	Infrastructural lacking	133	133/200= 0.6	Rejected

8	Pay Cut	147	147/200= 0.7	Rejected
9	No predefined SOPs/ Framework	539	539/200= 2.7	Accepted
10	Employee Loss	161	161/200= 0.8	Rejected
11	Product Deployment Issues	197	197/200= 0.9	Rejected
12	Scope Creep	221	221/200= 1.1	Accepted

Out of 12 challenges, 8 were accepted, and 4 were rejected. The accepted challenges include the 'Difficulty in Requirement Gathering, Mismanagement in Project Planning, Weak Performance, Drop in Work Quality, Economic Pressure, Miscommunication, no predefined SOPs/ Framework, Scope Creep'; these have scored more than 1 on the Likert scale, and the rejected ones scored less than 1. The scale was decided earlier for the acceptance and rejection criteria. Figure 4.2 shows the average weightage response against each challenge.

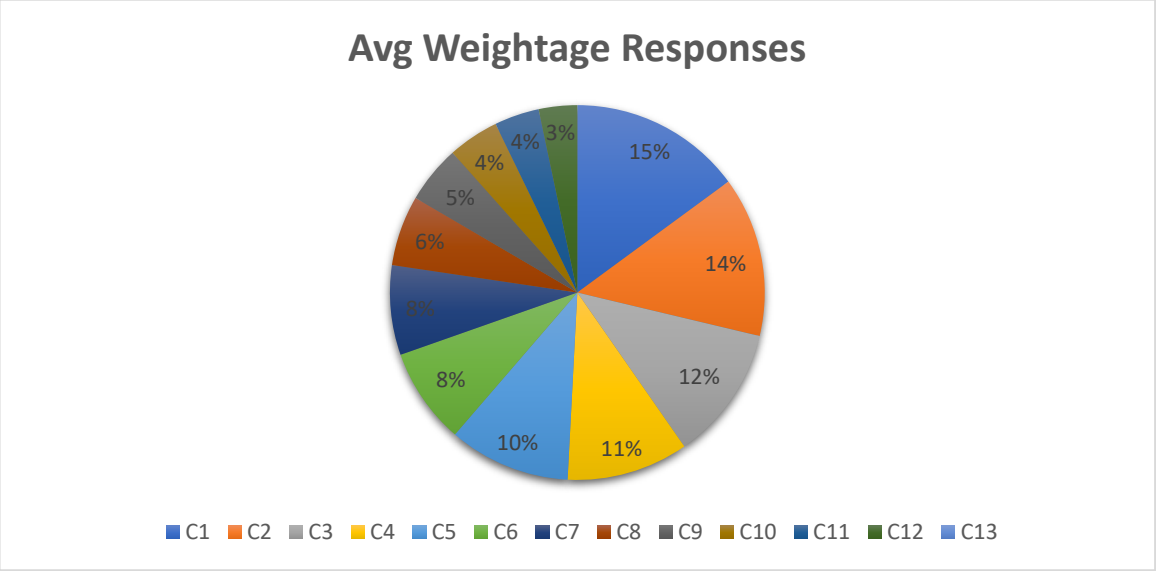

Figure 4.2: Average weightage Response

4.3 Results Explanation

The survey results are analyzed based on set criteria on the Likert scale values; values less than 1 were rejected, and values greater than 1 were accepted. Based on this criteria, 8 challenges got accepted, and four of them were rejected.

To further evaluate the results' consistency and reliability, we calculated Cronbach's Alpha values.

4.3.1 Cronbach's Alpha

It is essential to validate the scales used in a survey. A researcher looks for the reliability and consistency of a scale [78]. The survey results also depend significantly on how the scale is set and used for the data collection. To validate the scale used for this survey, it was a practice to calculate the Cronbach Alpha values for the different items. For Cronbach Alpha, values greater than 0.70 are considered reliable. In the following research, the values are computed and matched to the criteria of Cronbach alpha which made the 8 challenges reliable and valid.

4.3.2 Low Significance Challenges

A total of 4 challenges were rejected out of the 12 due to their lower average weightage values. Rejected challenges include product deployment, employee loss, pay cuts, and infrastructure adaptability.

I. Product Deployment Issues got rejected with an average value of 0.9. A minimal number of respondents have responded to Always facing this challenge.

II. Employee Loss got rejected with an average value of 0.8. Most respondents didn't face the challenge compared to the few who did.

III. Pay Cuts got rejected with an average value of 0.7. Respondents were not sure if they had to face a frequent pay cut through the Covid 19 era.

IV. Infrastructure lacking is rejected with an average value of 0.6. Surprisingly the respondents were happy to get adapted to the new online infrastructure.

4.3.3 High Significance Challenges

Most of the challenges got accepted; 8 out of 12 were above the set criteria of 1. The accepted challenges are the No SOPs/Framework, Requirement Gathering, Performance, Communication, Project Planning, Economic Pressure, Quality Assurance, and Scope Creep.

I. No predefined SOPs/Framework is an accepted challenge with an average value of 2.7. As most of the respondents believed that the lack of proper guidelines or frameworks had been the biggest challenge through Covid 19

II. Difficulty in Requirement's Gathering is another accepted challenge with a value of 2.5; as the respondents say, it was hard to collect the requirements without meeting the clients in person.

III. Weak Performance is an accepted challenge with an average value of 1.9, a downfall in performance has been reported by a more significant number of respondents.

IV. Miscommunication is a critical challenge that got accepted with an average value of 1.9; respondents had to face communication barriers due to the lack of physical meetings.

V. Mismanagement in Project Planning is a challenge accepted with a value of 1.5. Most respondents agreed that the Project Planning phase in the SDLC was a challenge during the pandemic.

VI. Economic Pressure is an accepted challenge with an average value of 1.4. Respondents agreed on the financial pressure.

VII. Drop in Work Quality is another accepted challenge with an average value of 1.1, as most respondents agreed on the drop in quality of work.

VIII. Scope creep is the last accepted challenge with an average value of 1.1; respondents have agreed on frequent requirements changes.

4.4 Explanation of Accepted Factor

The following section discusses the accepted factors in detail to see their significance and severity.

4.4.1 No predefined SOPs/ Framework

Challenges are a part of life, and they also have effects from slight to severe, but the real challenge is to have proper guidance and to come up with the right SOPs and a structured and authentic framework to continue with the work cycle. Work must not stop; it just can't stop. Although in an uncertain yet chaotic situation, it gets hard to formulate the right direction to keep moving.

During COVID-19, every individual faced uncertain and unplanned situations; it was challenging to centralize a thought and reflect on agility and adaptive governance [78]. Many respondents agreed that the companies, despite having some existing SOPs, could not develop a new and practical framework. And it turned out to be a challenge during covid-19.

4.4.2 Difficulty in Requirement's Gathering

Requirements gathering is the first step toward a new development project. If the requirements are not complete, structured, or to the point, the project can fail. Requirements are usually gathered in a meeting with a client, but during covid 19, it was not possible to arrange meetings and meet clients in person. Online discussions were new to many layman clients resulting in a challenging requirement gathering cycle.

Although the respondents faced a challenge bringing the team and clients on the same page, virtual sessions were new and hard to adapt. However, it is still suggested to adopt some improved and reliable engineering practices like blockchain technology [79]. Challenges are a new gateway to a successful way of meeting new heights of success and innovation.

4.4.3 Weak Performance

In observing the performance of an individual or the team's overall performance, in both cases, the performance was inclined downwards during the covid-19 pandemic. Performance is another accepted challenge with an average weightage of 1.9, showing how respondents agreed on the declining performance during the global pandemic.

There were many reasons, including physical and mental health issues [80], for the decrease in performance during COVID-19. And the effect was from individual to collective level. The pre- and post-pandemic performance comparisons took place in several studies to study the deviation, but not all the individuals reported lousy performance. Some were good too, and some did like the new work modes.

4.4.4 Miscommunication

Communication is an accepted challenge with an average weightage value of 1.9. if we talk about communication between teams and the communication between teams and clients, it was a

different story as most of the communication was one on one, in person, or physically connected. People used to have physical interactions, discussions, and meetings about work and daily life.

Then came the global pandemic that changed the definition of communication for almost every person around the globe. Physical communication became life-threatening, and to save lives; it was essential to shift to an online lifestyle, from medical to education, communicated over virtual mediums [81]. However, so many software development companies were already familiar with the idea of remotely working, online modes, and digital infrastructure but not all of them were.

So, the respondents from most companies with no experience working in distributed teams, online mode, and virtual meetings were unhappy after the Covid-19 change. It was difficult for many employees to adapt to a new way of communicating and staying in constant touch with their dispersed team members. It was nothing less than a challenge for so many individuals and teams.

4.4.5 Mismanagement in Project Planning

Project Planning is an accepted challenge, with an average weightage of 1.5. The Project Planning phase is one of the very initial phases of software development. The teams had to spend a reasonable amount of time focusing on Project Planning and documenting a roadmap for the work. One of the reasons for weak Project Planning could be the lack of physical interaction between teams.

In the traditional work environment [82], people were used to doing daily scrum meetings, Project Planning for the day, and acting accordingly. The sudden shift to an online mode was also new for Project Planning. And took a while to understand that technology can significantly help manage the Project Planning phase even when you are not in a single room with all possible resources.

4.4.6 Economic Pressure

The economic crisis was a great challenge, so the challenge was accepted with an average weightage of 1.4. The pandemic was disastrous, leading to the shutting down of the countries and overall operations around the globe [83]. This resulted in much distress and economic pressure on underdeveloped countries and small working units.

It is reported that economic pressure was felt by several organizations and also some software companies. However, the pressure was more on other industries that could not continue with the productions. The software industry managed to continue working on projects and development through a digital mode of working and deploying the projects. But the projects were less, the revenue collapsed, and economic pressure was built during the pandemic.

4.4.7 Drop in the Work Quality

Respondents agreed that keeping up with quality products during the covid-19 was challenging, which is why the challenge is accepted with an average value of 1.1. Quality is a serious matter; it leads to customer satisfaction and the success of a system. At the same time, it requires suitable work conditions, a focused and fit team, and the available resources needed.

Covid-19 was all about distancing and working in various new working environments. Working from home was an easy way to balance life for some people. Still, the quality of working in an onsite environment assess in positive and negative aspects from person to person. However, some of the respondents were happy with the quality of their work during the pandemic, while some needed extra support [84].

4.4.8 Scope Creep

Scope creep the last accepted challenge, with an average weightage of 1.1. This was another critical challenge during covid-19. Several reasons are fetched through the literature like the rework was due to the incomplete requirements or communication gap between client and team. But the

scope creep was one of the reasons for project delays, [85] cost overruns, and much distress among the customers and the team.

4.5 Summary

The chapter has discussed the results gathered through a survey questionnaire. The survey was responded by 200 people from different software companies working in various roles. The respondents were experienced in their field and had the experience of working during and after post covid era. As per the demographic details, all of them had an experience of more than two years in their respective fields.

Results are presented in tables and used for the analysis. Thirteen different challenges were highlighted and identified. The acceptance and rejection of various challenges were made based on the set criteria, any challenge with more than one value is accepted, and the challenges with a value less than one are rejected. The calculation is validated through Cronbach Alpha.

Out of thirteen challenges, nine are accepted, and four are rejected. After categorizing accepted and rejected challenges, an in-detail explanation for each accepted challenge was made. The purpose was to get a deep insight into why some specific challenge was severely affecting while some were not so. Hence, the challenges accepted have a broader impact on the lives of software development teams and need special attention towards them.

CHAPTER 5

DISCUSSION

5.1 Introduction

Chapter four shows the results of the survey conducted using a questionnaire. The results have highlighted the challenges faced by software development teams during COVID-19. Out of 12 challenges, eight were accepted by the average weightage value criteria, validated by Cronbach Alpha values. However, four of the challenges were rejected following the same procedure.

Chapter five will discuss the second research technique: one-on-one interviews with well-informed, experienced individuals working in different roles for software development teams in other IT companies. Five individuals are picked for the interviews working as Requirements Engineer, Designer, Developer, Quality Assurance Analyst, and Project Manager.

The last half of the following chapter will include the framework proposed using the results obtained from the interviews. Experts have suggested some mitigation techniques for the challenges faced during COVID-19. Furthermore, the framework proposed is validated by another set of experts with experience working in the field for more than ten years.

5.2 Triangulation Method

Triangulation is the use of multiple research methods to investigate a study; the purpose of using the triangulation method is to increase the conformity, validity, and reliability of the research work as multiple ways confirm the results from the previous method. The technique helps gather qualitative results [86] from different sources.

It is essential to ensure that the results are credible enough to form a conclusion. In that same case, it is an ideal way of using multiple research methods simultaneously to overlook the results from a single observer's side [87]. Triangulation is perfect when you need a variation in the data set as well; it can help observe a broader set of data to confirm the results.

The primary task of triangulation is to confirm the results of one method from another [88]. In the following study, the triangulation is done using two very in-depth research methods: A survey and interviews. An online survey is conducted, collecting around 200 responses, and it is later confirmed through interviews with the five experts. Fig 5.1 explains the triangulation method used in the following study.

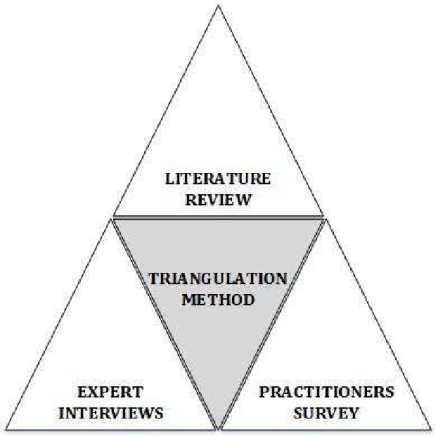

Figure 5.1: Triangulation Method

5.2.1 Interviews

Interviews are a qualitative method of collecting data, sometimes alone and sometimes in parallel with some other technique calling it a mixed method approach [89]. Interviews can get complex as the interviewer has a personal stance on the study topic, whereas the participants may have a different perspective. The only way out is to stay unbiased and open to every result.

In the following research, a structured interview has been conducted. Five experts participated in this interview. Each is a part of a software development team working for different positions: Requirement Engineer, Designer, Coder/Developer, Quality Assurance Analysts, and project manager. Interviews sound reliable and valid when they are more structured [90].

Therefore, in the following research, the discussion was based on a predefined set of questions. These questions are formulated carefully, keeping the survey questionnaires in mind. The interview questions are mapped with the survey questionnaire to enhance consistency. The goal is not just to get all the information but the most important information [91]. The interview consists of three open-ended questions and some counter questions to clarify the different point of views of the participants. These questions have helped us formulate the mitigation techniques**.**

Interviews are conducted by initially taking the demographic information of the individuals. The information validates that they were eligible to answer the interview questions. Figure 5.2 explains the demographic information showing the different roles of participants involved in the interview.

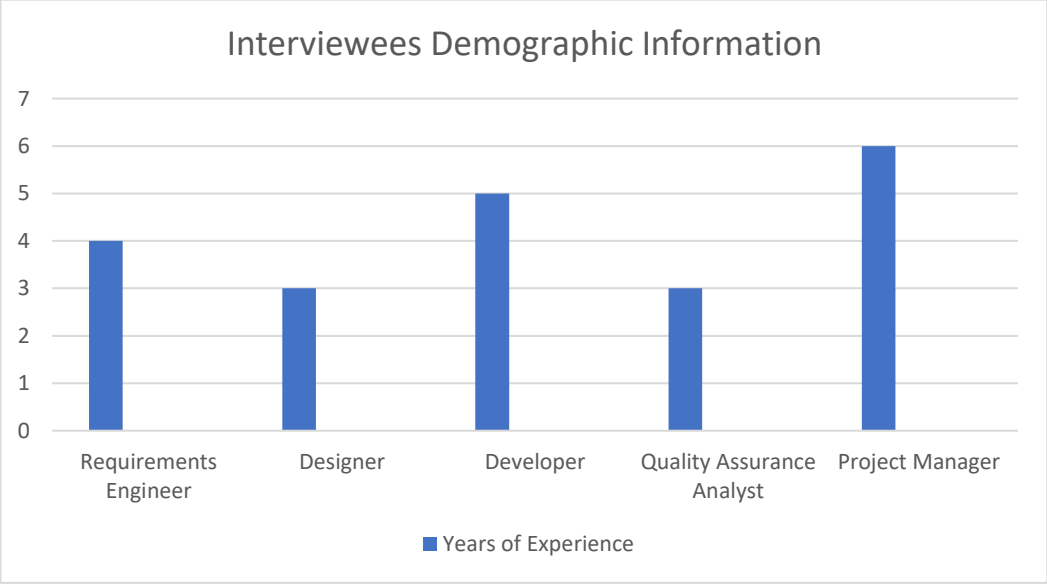

Figure 5.2: Demographic Info of Interviewees

5.3 Proposed Framework

A conceptual framework has been proposed in the following research based on the identified challenges and possible mitigation techniques gathered from the literature and interview results. Following are the components of the framework proposed alongside their potential usage.

5.3.1 Framework Development Process

A few planned steps are followed carefully while developing a conceptual framework.

I. To identify the components of the proposed conceptual framework, several studies are reviewed [92] and considered as an example of developing successful frameworks.
II. A systematic Literature review has been conducted in chapter 2 (section 2.1) to identify the challenges faced by the software development teams; a survey further helped collect the challenges through Practitioners, and interviews from the experts validate the results.
III. Literature and interview results helped find the mitigation techniques to cope with the highlighted challenges.
IV. The final step is consolidating of the identified challenges and the suggested mitigation techniques into a framework.

5.4 Components of Framework

The proposed framework is composed of two major components:

I. Accepted Challenges
II. Mitigation Strategies

Around 12 challenges have been identified from both the SLR and survey. Figure 5.3 shows the complete overview of the challenges identified and accepted and the possible mitigation techniques suggested by interviewees and validated by experts.

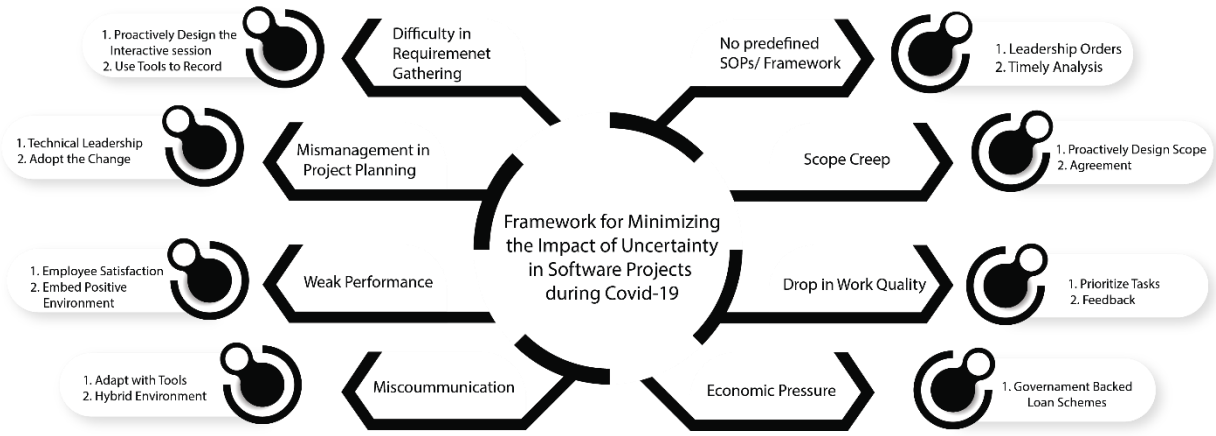

Figure 5.3: Proposed Framework

5.4.1 No SOPs/ Framework

Covid-19 was an unimaginable uncertainty, with no mitigation plans. Most of the companies had no SOPs to adapt to. It was one of the biggest challenges at first. Our respondents could not say if their companies had any proper guidelines to fight the dramatically changing work situation in COVID-19. To address the challenge, our experts have suggested the following mitigation techniques.

I. Leadership Orders

This is suggested as one of the critical strategies in case of no SOPs or guidelines to follow. Like COVID-19, when nothing was planned, the experts advised or suggested that the senior leadership should come forward to analyze the situation and give instant orders to be implemented, keeping every possible aspect in mind.

II. Timely Analysis

The step is followed after the higher authorities or the leadership gives the orders—immediately implementing the newly given advice and constantly monitoring the results. In case

of positive results, the orders can form SOPs for future use. If the results are not satisfactory, a change in orders should occur.

5.4.2 Difficulty in Requirements Gathering

Software development starts with requirements gathering; recent studies have shown a high project failure rate due to the incompetent requirement gathering process [92]. COVID-19 has affected the process; agile teams struggled a lot [93]. Respondents claim that the incomplete requirements resulted from the less interactive sessions between clients and companies; this was alarming for the software development life cycle. The suggested mitigation techniques are as follows:

I. Proactively design the interactive sessions

It is essential to gather maximum requirements when you know that you can't have so many follow-up sessions shortly. The new era of virtual sessions changed the way clients were able to connect with the team. It is advised to the teams to proactively design the whole session [94] with a maximum number of questions to gather enough information to keep working for a long time.

II. Tools to record

Ever since the Covid-19 outbreak, we have witnessed the industrial revolution to cope with the rising issues in every aspect of life. Industrial technologies are one of the new revolutions happening; the technologies help in taking control and managing work. Now many tools [95] can help arrange virtual meetings and record them for future use.

5.4.3 Mismanagement in Project Planning

Project planning is considered one of the most critical phases in a project's development. The plan is viewed as a roadmap for every individual involved in the working of the project.

Respondents believe project planning became challenging during COVID-19; most working techniques and methodologies were conventional and needed to be updated to cope with the new working environments [96].

I. Technical Leadership

Project planning is not a kid's game, especially in times of uncertainty. It is wise to let the best ones guide you. It is suggested that every company must have technical leads [97] to specifically work on creating solutions for adverse cases. They should keep generating various technical solutions to meet the needs of the hour.

II. Adapt the change

Everything changed after COVID-19 [98], how teams collaborated, communicated, planned, or developed their products. But the global pandemic has come with its lessons; one of them is to embrace change, adapt to new ways of working and have the agility to switch between various work environments.

5.4.4 Weak Performance

Everyone was affected by the global pandemic, and teams have reported a decline in performance during the stressful COVID-19. When people struggled with physical and mental health issues during those adverse times [99], teams found it challenging to give their best. A sudden change in the working methodology was nothing less than a challenge. Literature has shown several reasons for the declining performance of software development teams, including stress, isolation causing depression, unavailability of a comfortable workspace at home, and the list goes on.

I. Employee Satisfaction

It is suggested that companies should focus on employee satisfaction [100] during uncertain or complex times. Because employees are the real asset, keeping them satisfied is the biggest challenge for any organization. Companies must keep their teams comfortable and enthusiastic so that they may give their best at work.

II. Embed Positive Environment

COVID-19 was all about adversity and chaos around the globe. People were unhappy, struggling to restore their sanity during the most challenging time. It is suggested that the companies and management take up the responsibility to embed positivity in their teams. They must try to keep their work environment sustainable [101] and workable in times of hopelessness. That's how you can achieve performance.

5.4.5 Miscommunication

Communication has been the biggest challenge during COVID-19 for every human; social distancing, work from home, and self-isolation were hindering human collaboration to a destructive level. Nothing remained the same after the COVID-19 outbreak [102]. Software development teams have to constantly communicate with each other and with the customers as well. The virtual communication was a mixed experience for teams, some of the teams already working in remote setups found no difference, but an infrastructural change challenged those working on site.

I. Adapt with Tools

Communication in times of social distancing and work from home was solely done through virtual mediums. It is suggested that technological evolution must be accepted wholeheartedly, and adaptability with the tools should now be a part of the team's learning.

II. Hybrid Environment

Managing teams online and on-site are two different things [103]; balancing communication in both situations is never easy. But a hybrid environment can help offset the communication gap. Teams should keep visiting on-site to feel the same physical connection while getting flexible work-from-home options.

5.4.6 Economic Pressure

Economic pressure was one of the biggest challenges faced by small and medium-sized industries. Although the respondents didn't mention pay cuts or job loss at an extreme level, the downfall of GDP has affected almost every organization and nearly every country around the globe [104].

I. Government backed Loan Schemes

These industries, including software, contribute significantly to a country's GDP [104]. Developing government-backed loan schemes for industries is the best possible mitigation technique to sustain the economic pressure. Such schemes can help in need of tremendous financial pressure.

5.4.7 Drop in Work Quality

Keeping up with the quality of the developed products was a challenge during COVID-19. However, it is one of the critical factors in a project's success. Teams tried hard to create solutions to maintain quality during uncertain times.

I. Prioritize Task

To meet the quality of the product under development, the teams must prioritize the essential tasks on the list. The important tasks must be carried out in a more on-site presence by leaving less important ones for work from home [106].

II. *Feedback*

Feedback is the main element to keep your team high in spirit and your customer in a loop of trust. It is essential to have constructive feedback sessions within the teams and with the customer. Especially in times of chaos, building trust is the only way to success.

5.4.8 Scope Creep

Several respondents have reported that the frequently changing requirements and sometimes the lack of interactive follow-up sessions resulted in scope creep during Covid-19. It was hectic for the teams to rework while they had so much to deal with, parallel work schedules to meet, and being careful about mental and physical health.

I. Proactively Design Scope

If you know that an uncertain situation can lead to an increase in the set requirements, it is advised to proactively design a scope, list down everything you want the customer to accept, and keep a record of all their possible needs. Be vocal about the no rework agenda, encouraging the team.

II. Agreement

Legalize the project in all possible ways, keep multiple records, and record the sessions using the tools in case of virtual meetings. And keep reminding your customers what they asked and paid for.

5.5 Framework Validation

The proposed framework has been validated by a group of 5 experts with a working experience of almost 5 years in their respective fields. They are part of software development teams in different software companies.

Table 5.1 Demographic Information of Experts

Name	**Role/Designation**	**In Field Experience**
Interviewee 1	Software Project Manager	7 years
Interviewee 2	Developer	7 years
Interviewee 3	Quality Assurance Expert	5 years
Interviewee 4	Designer	6 years
Interviewee 5	Requirement's Engineer	5 years

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Overview

Chapter six will conclude the research work and give the future directions in the study. The chapter is outlined in the following steps: reviewing the research questions, the study has been done on two research questions so they would be covered in detail, including the findings for each one of them, step two discusses the novelty of the research, the research contributions made, limitations of the study and the future directions for the researchers.

6.2 Reviewing Research Questions

The sole purpose of the study was to identify the challenges faced by software development teams during Covid 19 and the possible mitigation techniques in the form of a conceptual framework. The following two research questions are addressed in this study:

RQ1: *What challenges were faced in software projects during COVID-19?*

RQ2: *How the proposed framework can cope with the identified uncertainties?*

6.2.1 Reviewing RQ1

The first research question was the crucial step in identifying the maximum number of challenges faced by software development teams during the COVID-19 pandemic. The research question was designed to get a list of hurdles affecting the software industry during the global

pandemic. A proper research methodology with multiple techniques was implemented to address the question.

First, a thorough systematic literature review was done using sources like springer, Elsewhere, Wiley, Google Scholar, and IEEE. The systematic literature review has helped a lot in understanding the global issues, the challenges in different work cultures, and the possible remedies they could adapt to within the limitations of their resources.

Furthermore, a survey was conducted online to collect the data that could address the needs of the first research questions. So, the questionnaire was developed carefully, keeping the requirements in mind. The survey has been responded to by 200 individuals from all over Pakistan working in the software industry with multiple years of experience in different team roles. The survey has helped in identifying more challenges.

The survey result is of great importance because the local community of Pakistan responds to that. It aimed to study the work culture of Pakistan's software industry during the pandemic and to see how retaliating they were. Surprisingly several challenges, including pay cuts and job loss, were taken quite generally by the software industry of Pakistan, which was an unexpected finding as most countries have done it on a mass level.

The survey result has been analyzed and presented in the form of tables. The average weightage values are calculated to choose accepted and rejected challenges for the following research, out of 12 challenges covering almost all the significant aspects of a software development life cycle and the overall work culture of Pakistan's software industry. The rejected challenges were also of great importance but the criteria set above them.

The identified and accepted challenges are the outcomes required for the first research question; However, the list of challenges can be endless. The ones identified in this study are well structured and carefully included to avoid repetition. The study's challenges also cover so many derived challenges hidden underneath.

6.2.2 Reviewing RQ2

The second research question is solution oriented; it is based on further planning over the issues identified by the first research question of the study. The research question was also a part of the survey and the interviews. It was essential to know how most of our companies had no frameworks for challenges like COVID-19. The first challenge identified has the maximum average weightage value; the challenge has shown the need for SOPs and frameworks during the pandemic. So, the first challenge answered the need to address the second research question.

With an average weightage of 2.7, the challenge of no pre-defined SOPs put the software development teams under tremendous pressure. The lack of proactive planning was upsetting and discouraging for the employees during the difficult times of COVID-19. It has affected the management as well. But the sole purpose of proposing a framework was to help the administration with the idea of having proactive frameworks for different uncertainties.

The proposed framework is developed with the help of interviews with five experts in different roles, including Requirement Engineers, Designers, Developers, QA Analysts, and Project managers. The experience of each one of them is more than five years in their respective fields. The interviews were conducted in a structured form, with pre-defined questions; some of the counter questions were also recorded on the spot. But the findings have helped us validate the survey and get the suggestions to transform into mitigation techniques.

After collecting the information through interviews, a dry run of a framework was designed and validated by five more experts from the industry with an experience of 10+ years in their respective fields. After the validation of the proposed framework, it is discussed in detail with all the mitigation techniques. The techniques have cleared the understanding of the possible solutions in the relevant uncertain situations to COVID-19. Mitigation techniques are gathered and formulated with collective knowledge from the literature and the interviews.

The proposed framework has room for future work and further study on the topic. More mitigation techniques can be identified and added to the list. An industrial case study can help implement the framework for a better understanding and validation of the work. This would improve the credibility of the work done in this study.

6.3 Novelty of Research

The following research was started in the peak time of the year 2020, when COVID-19 was one of the biggest challenges the world was facing. It was created when the 3rd wave of COVID-19 was destroying the globe. It was a significant concern for most researchers to help the community by all means. The idea was inspiring because a few people had covered Pakistan's software industry.

The research has identified some of the new challenges and valuable mitigation techniques by keeping the local working culture of Pakistan in mind. The aim was to help the local community first. The SOPs or frameworks are constantly changing, with versions and updates, but the purpose is to make a path for many to follow.

6.4 Research Contribution

The study has contributed to identifying significant challenges faced by software development teams and the industry. As soon as we highlighted the problem, the solution was also given as a proposed framework. The research work has covered two sustainable development goals:

6.4.1 Contribution based on SDGs

I. Decent work and economic growth with sustainable development for everyone.
II. promote the inclusive and sustainable industry to foster innovation.

Suppose the industry learns to work on the identified challenges using the proposed mitigation techniques. In that case, there is a possibility of economic growth and overall stability in the production and performance of the teams.

It has been made clear by the research that if the industry.

6.5 Limitations

Although the accepted challenges and the suggested mitigation techniques are well researched and validated by peers in the field, the following limitations exist for this study:

I. A single researcher has done the literature review for this study; there is a possibility of missing any vital information, article, or case study.
II. Although the framework has been validated by five experts from the field yet, no industry-based case study has been implemented to validate the framework.

6.6 Conclusion and Future Work

The framework's validation has been done through experts in different software industry roles. But the framework has not been validated through proper implementation in an industrial setup. The expert opinion still has room to be covered which can be done if the framework is implemented in the industry with the proper monitoring of the overall performance. More challenges can be added to the list of identified challenges, and several mitigation techniques can be suggested for every challenge, based on the experiences that the study has missed due to any reason.

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APPENDIX A

Research Quality Protocol

Screening Question Is the study title relevant to the topic under research? - Is the paper based on the same title?	Yes ☐ NO ☐
Screening Question Is there a clear indication of the context in which the research is being carried out? Whether the researcher has: - Indicated the software industry? - Indicated the pre and posted covid 19 eras? - Indicated the software development teams? - Indicated the issues faced by the software development teams globally?	Yes ☐ NO ☐
Screening Question Is the paper highlighting the challenges to support the research questions? Whether the researcher has: - Indicated the global challenges faced during and post covid 19 eras? - Indicated the list of challengescaused by the global pandemic for the software industry?	Yes ☐ NO ☐
Research Design Was the research design sufficient to indicate the concerning factors? Whether the researcher has:	Yes ☐ NO ☐

✚ Indicated that the research design was good enough to get satisfactory results? ✚ Indicated the reason for choosing a particular research design?	
Sampling Is the literature of the paper addressing the need of the research questions? ✚ Whether the literature was supporting the research questions?	Yes ☐ NO ☐
Data Collection Was the data collected in a way that addressed the concerning issue? ✚ Is it clear how data was collected? ✚ Were the methods used justified? ✚ Whether the quality controls applied for the collected data's completion and accuracy?	Yes ☐ NO ☐
Data Analysis Was the data analysis helpful enough to answer our research concerns? ✚ Has sufficient data been presented to support the results? ✚ Was there any description of the data analysis process?	Yes ☐ NO ☐
Findings Is the study valuable for researchers in this field? ✚ Has the researcher discussed the credibility of his study? ✚ Are the findings related to the research questions? ✚ Are the conclusions justified by the findings?	Yes ☐ NO ☐

Appendix B

Data Extraction Form

Study Description	
1. Study Identifier	Unique ID for the study
2. Date of Data Extraction	..
3. Bibliographic Reference	Author, year, source, title
4. Type of article	Journal article, conference paper, book section
5. Aim of Study	What were the aims of the study?
6. Design of Study	Qualitative, Quantitative
7. Data Collection	How was the data collected? (Forms, Excel Sheet)
8. Data Analysis	Qualitative, Quantitative
Study Findings	
1. Findings and Conclusions	What were the findings and the conclusions from the study?
2. Validity	Threats to validity
3. Relevance	Research

Appendix C

Content Validity Form for Questionnaire

Expert's opinion on the questionnaire fulfilling the need to address the title "Framework for Minimizing the Impact of Challenges in Software Projects during Covid-19".

Scale:

1 = The item is highly relevant, 2 = The item is somewhat appropriate, 3= The item is relevant.

4= The item is not relevant at all.

Definition: Validation of the questionnaire by requirements engineer, developer, Analyst, Tester/QA, and Project manager to validate the issues experienced during COVID 19, their severity, importance to be included in the research, and overall effect on software development life cycle during the COVID 19.

Testing Items	**Relevance Scale**
How difficult for the software companies during the covid 19 to gather customer requirements without meeting them in person?	**1 2 3 4**
How hard was it to bring customers and the software development teams on the same page by organizing virtual meetings during the covid 19?	**1 2 3 4**
How did the physically absent or distributed teams during covid 19 affect the planning phase of software development?	**1 2 3 4**
Did you find any misalignment between required and deployed software products during the COVID-19 era?	**1 2 3 4**

Did you face scope creep in software development projects during the covid 19?	**1 2 3 4**
Have you seen a negative shift in the performance of the software development teams during work from home era of Covid 19?	**1 2 3 4**
Was there a drop in quality standards of the deployed software products during the covid 19?	**1 2 3 4**
How pressurizing was the economic condition for your software company during COVID-19?	**1 2 3 4**
Have your software company fired or lost any employee(s) due to financial instability during the Covid 19?	**1 2 3 4**
Did your software company apply any pay cut during the COVID-19 era?	**1 2 3 4**
Was it hard for your software development teams to adapt to the working infrastructure by shifting to the online mode during the covid 19?	**1 2 3 4**
Was the communication gap the most challenging constraint for the software development teams during the covid 19?	**1 2 3 4**
How effective can a framework be for the future guidance of software development teams in need of challenges as considerable as covid 19?	**1 2 3 4**

Appendix D

Interview Results

Challenges	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5
No SOPs/Framework	Adapt the similar ones	Develop new	Improve existing ones	Team up to make new	Take Leadership orders
Difficulty in Requirement's Gathering	Proactive planning	Pre-design Q/A	Plan the session	Record the process	Reconfirm the Reqs
Mismanagement in Project Planning	Increase strategies	Add more technical team	Embrace change	Prepare for scenarios	Practice change
Weak Performance	Employee satisfaction	Embed positivity	Boost team's morale	Checkup on team	Divide work
Miscommunication	Adapt to change	Test various tools	Hybrid mode	Maintain physical mode too	Use latest technology
Economic Pressure	Subsidy for industry	Companies plan for the worst	Backup saving plans	Government-led help	Balanced hirings
Drop in work Quality	**Prioritize tasks**	**Important tasks on site**	**Customer in loop**	**Constant feedback**	**Proactive plan**
Scope Creep	**Design scope**	**Draw boundaries**	**Multiple records**	**Agreements**	**Consent forms**

Appendix E

List of Software Companies

s/no	Software Companies	No of participants
1	All Tech 360	5
2	Sign Up Solution	8
3	A2Z Soft	10
4	Growstep Technologies	15
5	Codexier Software House	11
6	Sol Freak	7
7	Xorlogics	18
8	Techy Storm	8
9	Funavry	10
10	MMM Technology	13

11	REX Technologies	4
12	IT Genesis	9
13	United Software	15
14	TechnoLyte	12
15	Arbisoft	11
16	AWA Software	17
17	MangoTech Solution	12
18	Pixus Technology	10
19	NanoSoft Technology	5
20	10 Pearls	10

Appendix F

SURVEY QUESTIONNAIRE

1. How difficult was the requirement's gathering process during Covid-19?
    - High
    - Moderate
    - Low
2. How did the physically absent or distributed teams affect the planning phase of software projects?
    - To a great Extent
    - Somewhat
    - Not at all
3. Have you witnessed any misalignment between required and deployed product during the COVID 19 era?
    - Always
    - Usually
    - Never
4. Did you face frequently changed scope due to the lack of connectivity between the team and the end user?
    - Very Frequently
    - Occasionally
    - Never
5. Did you feel a negative shift in the work performance during work from home?
    - To a great Extent
    - Somewhat
    - Not at all
6. Was there a drop in quality standards of the deployed products due to the pandemic?
    - To a great Extent
    - Somewhat
    - Not at all
7. Was communication barrier the most affecting constraint during the global pandemic?
    - Strongly Agree
    - Somewhat
    - Strongly Disagree
8. How pressurizing was the economic condition for your company during COVID-19?
    - To a great Extent
    - Somewhat
    - Not at all
9. Have you observed a job loss due to financial instability during the pandemic?
    - Very Often
    - Sometimes
    - Not at all
10. Did your software company apply any pay cut during the COVID-19 era?
    - Yes
    - No
    - Maybe
11. Was it hard to change the working infrastructure by shifting to the online mode?
    - Strongly Agree

- Moderately
- Strongly disagree

12. Were there any proactive guidelines or basic company SOPs for any such big uncertainty?
    - Yes
    - No
    - Maybe
13. How effective can a framework be for future safety against uncertainty?
    - Extremely
    - Moderately
    - Not at all