

**WORKFORCE MANAGEMENT, SAFETY,
HEALTHCARE AND WELFARE STRATEGIES IN
CONSTRUCTION SITES IN THE CONTEXT OF
COVID-19 PANDEMIC**

BY

U.W.A.N. Niroshana

Supervised by

Dr. Chandana Siriwardana

“The dissertation was submitted to the Department of Civil Engineering of the University of Moratuwa as a partial fulfilment of the requirements for the Master of Science in Construction Project Management”

Department of Civil Engineering

University of Moratuwa

Sri Lanka

June 2022

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

20.06.2022

.....

.....

Signature of Candidate

Date

The above candidate has carried out research for the Masters thesis under my supervision.

.....

.....

Signature of Supervisor

Date

DEDICATION

This thesis is dedicated to my loving Parents, Wife and Family.

ACKNOWLEDGEMENT

To complete this research study successfully, a great assistance was received from many people and organizations. Therefore, I use this opportunity to express my sincere thanks to all of them.

First, I would like to be grateful to the Course Coordinator and my Research Supervisor, senior lecturer Dr. Chandana Siriwardana, for his guidance and supervision of this study and for the encouragement which made the work success.

Then my sincere thanks go to the Post Course Coordinator, Prof. Asoka Perera, Senior Lecturers, Lecturers and all other Staff Members of the Department of Civil Engineering for their advice and immense support towards the successful completion of this research study.

Further, I would like to express my thanks to all the industry practitioners who gave me an immense support to complete this research successfully by spending their valuable time and extending kind cooperation through interviews conducted in case studies.

Last, I express my heartfelt gratitude to my family and friends for willingly giving me their utmost support, advice and continuously motivating me to carry out the work successfully.

ABSTRACT

As the World Health Organization (WHO) declared the COVID-19 (Coronavirus 2019) outbreak as a pandemic, many countries have declared national lockdown in 2020. This unexpected lock down situation has mainly restricted the movement of people and performance of services. Finally, it has resulted in a full shutdown of the business sector and other industries globally. The construction industry in Sri Lanka is considered a significant sector of the national economy with no exception. Government of Sri Lanka (GOSL) declared an island wide lockdown for 52 days completely due to the COVID-19 pandemic and all the construction projects across the country were shutdown accordingly.

Therefore, the effect of COVID-19 on the construction industry in Sri Lanka will be investigated and analyzed through this research study. The impact for certain areas in the construction sector has been determined and analyzed using the feedback from experts in the industry. For the research study, the effect has been classified into different sectors which include workforce management, health and safety practices, welfare facilities and preparation for emergency and pandemic situations in construction sites. The study was carried out through a questionnaire survey which confirmed that the lockdown of construction sites had a high impact on the site activities, construction methods, management processes, safety and healthcare practices. The findings of this study will help to understand the consequences of a sudden occurrence of pandemic situations in the future and raise awareness in the industry. In addition to that, the outcome will help the project managers to plan for the worst-case scenario during the design and planning stages of construction projects.

It has been considered that Sri Lanka is one of the most vulnerable countries in the world because of the COVID-19 outbreak. Financial System of Sri Lanka is mainly dependent on the foreign investment and trade. Therefore, both direct and indirect impact to the economy and other sectors can be expected including the construction industry. As the COVID-19 pandemic has started to continue since December 2019, lockdowns have been imposed around the globe several times. This has changed the day-to-day physical activities to online activities everywhere. However, it is impossible to perform some activities remotely. For instance, construction activities are not possible to carry out virtually. In addition to that, in Sri Lanka, it is not practical to

maintain social distancing in construction industry as this sector is totally dependent on the manpower. Construction sites had been disturbed by their material supply chains and workforce due to the lockdown situations and various quarantine procedures. Therefore, COVID-19 pandemic has highly disrupted the construction industry in Sri Lanka. As the construction sector contributes a significant amount to the economy of Sri Lanka, it is essential to continue the construction activities according to the health and safety measures while reducing the spread of COVID-19. This research study has found that the workforce has been reduced by 30% to 90% in the construction sector due to the spread of Covid-19. This implies that construction project managers have to forecast and plan the future construction activities considering adequate health and safety measures for workers at construction sites and dormitories while maintaining minimum chances of spreading COVID-19 virus.

This research study is based on the primary data collected from the officials who are from the top management and middle management levels in various construction projects in Sri Lanka through an online questionnaire survey. The outcomes of this study have indicated that there is a significant effect to the construction industry of Sri Lanka due to COVID-19 pandemic. Therefore, effective policies and procedures should be utilized to mitigate the consequence of the Pandemic in the construction industry in Sri Lanka.

Key words: Pandemic, COVID-19, impact, Construction, Sri Lanka

TABLE OF CONTENTS

DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT.....	v
TABLE OF CONTENTS.....	vii
LIST OF TABLES	xi
LIST OF FIGURES	xii
ABBREVIATIONS AND ACRONYMS	xiv
CHAPTER ONE	1
1.0. INTRODUCTION TO THE RESEARCH	1
1.1 Background	2
1.2 Problem Statement	3
1.3 Research Objectives	3
1.4 Problem Justification.....	4
1.5 Significance of the Research.....	4
1.6 Methodology	5
1.7 Limitations of the Study.....	6
1.8 Guide to the Report	7
CHAPTER TWO	8
2.0. LITERATURE REVIEW	8
2.1 Introduction.....	8
2.2 History of Pandemic Situations in Sri Lanka	9
2.2.1 Overview of COVID-19 Pandemic	9
2.2.2 Dengue Pandemic	11
2.2.3 Vulnerability of Construction Industry for Pandemic situations	12

2.3 Changes of Construction Industry due to COVID-19.....	12
2.4 Effect of COVID-19 pandemic for Construction Sites.....	13
2.4.1 Workforce management.....	13
2.4.2 Health and Safety strategies.....	14
2.4.3 Providing Welfare facilities.....	15
2.4.4 Preparing Construction Sites for Emergency and Disaster.....	17
2.4.5 Changes of Construction Methods with Covid-19 Pandemic.....	18
2.5 Hierarchy of Control Measures in Construction Sites.....	19
2.6 Summary.....	20
CHAPTER THREE.....	21
3.0 RESEARCH METHODOLOGY.....	21
3.1 Introduction.....	21
3.2 Research Process.....	21
3.2.1 Literature Review.....	21
3.2.2. Research Problem Statement.....	22
3.2.3 Application of Survey Method for the Research.....	22
3.2.4 Questionnaire Development.....	22
3.2.5 Data Collection.....	24
3.2.6 Data Analysis.....	25
3.3 Summary.....	26
CHAPTER FOUR.....	27
4.0. ANALYSIS AND RESULTS.....	27
4.1 Introduction.....	27
4.2 Data Analysis.....	27
4.2.1 General Information of Respondents.....	27
4.2.2 Workforce Management.....	30
4.2.2.1 Workforce Composition.....	30

4.2.2.2 Difference between Local and Foreign Workforce	32
4.2.2.3 Standard working hours and Over time works.....	33
4.2.2.4 Paying salary for workers and staff.....	34
4.2.2.5 Reducing workforce during lockdown period.....	35
4.2.2.6 Factors for selecting workers/staff to Terminate Jobs.....	36
4.2.2.7 Factors considered when selecting workers/staff for calling back.....	40
4.2.2.8 Future Construction methods and strategies	44
4.2.2.9 Challenges faced regarding workers' management.....	46
4.2.3 Health and Safety	47
4.2.3.1 Consideration of workers/staff about their health and safety.....	47
4.2.3.2 Safety and medical officers in construction sites	48
4.2.3.3 Wearing Personal Protective Equipment (PPE) at site.....	49
4.2.3.4 Medical facilities Provided at sites.....	50
4.2.3.5 Sanitary practices of workers at sites and dormitories	51
4.2.3.6 Safety and Health Control measures to avoid COVID-19	52
4.2.3.7 Health and Safety Procedures had to be followed when back to work	52
4.2.3.8 Challenges faced regarding health and safety at sites	53
4.2.4 Welfare Facilities	54
4.2.4.1 Providing Accommodation for Workers	54
4.2.4.2 Facilities Provided for Workers	56
4.2.4.3 Physical Conditions of a Dormitory room	58
4.2.4.4 Sharing common facilities between workers at dormitories	58
4.2.4.5 Challenges faced when providing welfare facilities.....	59
4.2.5 Emergency and Disasters	60
4.2.5.1 Dengue Outbreak.....	60
4.2.5.2 COVID-19 Outbreak	61
4.2.5.4 Preparation for Emergency situations, disasters, and pandemics.....	62

4.2.5.5 Usage of Covid-19 Guidelines and References.....	63
4.3 Summary	64
CHAPTER FIVE	65
5.0. DISCUSSION	65
5.1 Introduction.....	65
5.2 Summary of the Study.....	65
5.3 Summary of the Findings.....	66
CHAPTER SIX	69
6.0. CONCLUSION AND RECOMMENDATIONS.....	69
BIBLIOGRAPHY	75
ANNEXURES	79
ANNEXURE – 1.....	80
ANNEXURE – 2.....	80

LIST OF TABLES

Table 2.1: Survival Durations of Covid-19 virus on different surfaces	10
Table 3.1: Time phases used to collect data for the Questionnaire Survey	23
Table 4.1: Number of days the construction sites were fully locked-down	30
Table 4.2: Changes of Construction method and strategies with Covid-19	44
Table 4.3: Conclusion of results of the paired sample T-test	45
Table 4.4: Correlation between General PPE and PPE used for COVID-19	50
Table 4.5: Health and Safety Procedures - workers follow when report to work	52
Table 4.6: Health and Safety Procedures - staff follow when report to work	53
Table 4.7: Media of how people heard about COVID-19	61
Table 4.8: Output of paired sample T-test for preparation methods for emergency	63
Table 6.1: Summary of main challenges faced and recommendation.	71

LIST OF FIGURES

Figure 1.1: Research Methodology	6
Figure 2.1: Process of Risk Assessment (Uzun, Bilir, & Cebi, 2018)	19
Figure 2.2: Hierarchy of Controls (Uzun, Bilir, & Cebi, 2018)	20
Figure 4.1: Cross Section of respondents (Company type)	28
Figure 4.2: Cross Section of respondents (Job Role)	28
Figure 4.4: Number of construction project handle by the companies	29
Figure 4.5: Workforce composition in construction sites	31
Figure 4.6: Planning to Change the workforce composition in future	31
Figure 4.7: Difference between local and foreign workforce	32
Figure 4.8: Fluctuations of standard working hours in construction sites	33
Figure 4.9: Allowable overtime works for workers and staff	33
Figure 4.10: Paying salary for workers and staff	34
Figure 4.11: Reducing workforce during lockdown period	35
Figure 4.12: Number of jobs reduced during lockdown period	35
Figure 4.13: Subsequent actions taken by the reduced foreign workforce	36
Figure 4.14: Concern on Basic Salary to terminate jobs	37
Figure 4.15: Concern on Performance to terminate jobs	37
Figure 4.16: Concern on Health Condition to terminate jobs	38
Figure 4.17: Concern on age limit to terminate jobs	38
Figure 4.18: Concern on working experience to terminate jobs	39
Figure 4.19: Concern on Nationality to terminate jobs	39
Figure 4.20: Concern on ‘distance from home’ to terminate jobs	40
Figure 4.21: Concern on Basic Salary for calling back to work	41
Figure 4.22: Concern on Performance for calling back to work	41
Figure 4.23: Concern on Health Condition for calling back to work	42
Figure 4.24: Concern on Age level for calling back to work	42
Figure 4.25: Concern on Experience for calling back to work	43
Figure 4.26 : Concern on Nationality for calling back to work	43
Figure 4.27 : Concern on ‘Distance from home’ for calling back to work	44
Figure 4.28: Variation of Challenges faced regarding workers’ management	46
Figure 4.29: Concern of workers and staff about their health and safety	47

Figure 4.30: Number of Safety and medical officers in construction sites	48
Figure 4.31: Key roles and responsibilities of safety officers	48
Figure 4.33: Variation of Medical facilities Provided at sites	50
Figure 4.34: Variation of Sanitary practices of workers at sites and dormitories	51
Figure 4.35: Variation of Safety and Health Control measures	52
Figure 4.36: Variation of Challenges faced regarding health and safety at sites	53
Figure 4.37: Providing Accommodation facility inside the site	54
Figure 4.38: Providing Accommodation facility Outside the site	55
Figure 4.39: Workforce without company provided Accommodation facility	55
Figure 4.40: Facilities Provided for workers in dormitories located inside the Sites	56
Figure 4.41: Facilities Provided for workers in dormitories located outside the Sites	56
Figure 4.42: Facilities provided who do not have dormitories	57
Figure 4.43: Physical facilities Provided for workers in dormitories	58
Figure 4.45: Sharing common facilities at dormitories	59
Figure 4.46: Percentage of Dengue Outbreak experienced at construction sites	60
Figure 4.47: Report of Dengue patients and deaths at construction sites	60
Figure 4.48: Responses about hearing Covid-19 before	61
Figure 4.49: Expectation of a pandemic situation in Sri Lanka	62
Figure 4.50: Usage of Covid-19 Guidelines and References	63

ABBREVIATIONS AND ACRONYMS

CIDA	-	Construction Industry Development Authority
GOSL	-	Government of Sri Lanka
GDP	-	Gross Domestic Product
ICTAD	-	Institute of Construction Training and Development
MERS	-	Middle East Respiratory Syndrome
PPE	-	Personal Protective Equipment
SARS	-	Severe Acute Respiratory Syndrome
SOP	-	Standard Operation Procedure
SPSS	-	Statistical Package for the Social Sciences
WFH	-	Work-From-Home
WHO	-	World Health Organization

CHAPTER ONE

1.0. INTRODUCTION TO THE RESEARCH

COVID-19 (Coronavirus 2019) is considered as a highly transmissible respiratory disease and scientists have already discovered that COVID-19 virus is originating from the SARS-CoV-2 virus. Currently, Covid-19 has converted to a pandemic that has infected millions of people and has become responsible for thousands of deaths worldwide. Most of the countries in the world including Sri Lanka are suffering from the Covid-19 outbreak. (Health and Immunity Enhancement Guidelines for Covid-19 and Dengue, 2020).

Most areas of economic life in Sri Lanka and the world have been highly impacted by the Coronavirus (COVID-19). Al Amri and Marey (2020) pointed out that the world is attempting to minimize the spread of the virus and trying to mitigate its effect. The Covid-19 disease has been initially identified at Wuhan city in China in 2019 and it has been created by Severe Acute Respiratory Syndrome (SARS) (Hui, 2020). The disease started to spread drastically all over the world and World Health Organization (WHO) declared it as a pandemic (WHO, 2020).

According to the study carried out by Wickramaarachchi, Perera, and Jayasinghe (2020), it is stated that the ongoing COVID-19 outbreak which was originated in Wuhan City has highly affected to the global economy and the life cycle of the world population. A Chinese national tourist was reported as the first COVID-19 case in Sri Lanka in late January 2020 and the first local case was reported in March 2020. Subsequently, the Government of Sri Lanka (GOSL) immediately initiated various controlling measures to minimize the spread of the virus within the community such as closing of education institutes, offices, airports, introducing remote work concept, limiting public gatherings and ban travel from other countries. Finally, island wide curfew was imposed expecting to slowdown the spread of virus and to decrease pressure on the healthcare system of Sri Lanka.

Several sectors in the world have been highly affected by the COVID-19 pandemic since it has spread quickly between many countries. In general, the economy in the world has faced a significant impact from the COVID-19 outbreak. As a result of that, several

business activities have been terminated while other economic activities slowed down and most of the countries faced economic downturn. However, many enterprises around the world have changed their work procedures and shifted to Work-From-Home (WFH) concept to survive their business and services (Gamil & Alhagar, 2020).

Construction industry is considered as a different sector compared to the other industries as all the workers, technical staff and engineers are always required to physically work at the construction sites to perform construction work and to examine the ongoing construction work. In addition to that, typically in the construction industry, it is necessary that the physical involvement of the full workforce to proceed construction activities effectively. Therefore, it is essential to study and analyze the methods and strategies used by the construction industry in Sri Lanka to handle this unexpected pandemic situation.

Construction sector of Sri Lanka is highly affected from the COVID-19 pandemic as most of the construction sites had to be shut down more than 50 days following the government health regulations. To minimize the chance of getting contaminated with COVID-19, most of the construction sites altered their day today site activities and has undertaken safety and health precautionary measures. Therefore, it is essential to study and find out the impact of COVID-19 to construction industry.

Therefore, this study aims to analyze the effect of COVID-19 pandemic for workforce management, safety and healthcare arrangement and procedures, welfare facilities and preparation for emergency in construction projects in Sri Lanka.

1.1 Background

Initially, most of the construction projects planned to minimize the propagation of the virus in workplaces and dormitories considering that social distancing in construction sites. However, as construction workers perform a major role of construction projects, reducing workforce in the construction sites has directly impacted the progress of works (Araya, 2020).

During the initial stage of COVID-19 pandemic, the lack of construction material supply to the construction sites severely weakened the progress of work and it has severely affected the whole construction industry in Sri Lanka. To decrease the spread of the virus in the community, many countries implemented several measures to reduce the freedom

of movement in public places. Therefore, it has mainly affected and obstructed the construction activities as every project member must be physically present at the work site to closely monitor work activities in construction sites. (Gamil & Alhagar, 2020).

Gamil and Alhagar (2020) further elaborated that most jobs in the construction sector have been lost as the small enterprises were not able to pay remunerations to the workforce during lockdown period. However, literature related to this subject matter is still limited especially the information relevant to the construction field. Hence, investigating the impact of the COVID-19 pandemic for the construction industry is essential for the future planning and arrangements.

1.2 Problem Statement

It is a well-known fact that day-to-day activities in our society have been significantly disrupted by the current pandemic due to COVID-19 since social distancing is the only way to reduce the spreading of the COVID-19 virus. As a result of that, most of the working activities which are dependent from human involvement have been replaced by virtual activities, such as working from home, online shopping, online learning for schools and universities. However, some activities are not possible to be carried out remotely, such as construction works. Because of that, facing COVID-19 pandemic was a huge challenge to the construction sector. The lockdowns imposed by GOSL due to COVID-19 to reduce the outbreak has significantly affected the lifestyles in Sri Lanka. Almost all Construction projects are delaying and halting due to the interruption of the construction material supply chain and shortage of workers. In addition to that, construction sites and workers' dormitories are considered highly prone to generate COVID-19 clusters as they are highly populated and dense areas. Construction industry is identified as critical sector for any pandemic situation as it is very difficult to maintain safety and health measures. For example, in Singapore, COVID-19 pandemic spread based on construction sites and workers dormitories (Araya, 2020).

1.3 Research Objectives

The main aim of this research is to carry out in-depth analysis to find out the impact of COVID-19 for the construction sites in different directions and determine the necessary strategies and management processes required to implement in construction sites to face

any pandemic situation in the future. The aim of the research will be met through the following objectives.

1. Analyzing the workforce management processes and strategies.
2. Investigating the health & safety practices and strategies.
3. Evaluating the welfare facilities that the construction sites provide
4. Examining the preparation of construction sites for emergency, disasters and pandemic situations.

1.4 Problem Justification

Meade (2020) stated that the ongoing COVID-19 pandemic is considered as an unforeseen threat to the world, and it has already produced many deaths, health problems and collapsing economies of many countries. GOSL has executed numerous restrictions focusing at controlling the ongoing pandemic. Some of the controlling measures implemented to control the spreading of pandemic are, lockdown identified areas, tracing of first contacts, quarantine procedures, case detection, travel bans and isolation of identified areas. However, regardless of controlling measures, the virus spreads continuously threatening the people, increasing the number of daily reported cases (Mahasinghe, Erandi, & Perera, 2020).

Since Sri Lanka is still a developing country, the required hospital facilities to cure COVID-19 patients in Sri Lanka are very limited. Therefore, it is very crucial to realize how successive control measures should be established to control the ongoing pandemic.

1.5 Significance of the Research

Currently, Construction industry plays a significant part of the National Economy in Sri Lanka as approximately 7% to the Gross Domestic Product (GDP) is contributed by the construction sector. In addition to that construction industry has created almost 500,000 employment opportunities directly and indirectly improving living standards of people. Therefore, any drop in the construction sector because of the epidemic situation will highly affect the national economy of Sri Lanka (Health and Immunity Enhancement Guidelines for Covid-19 and Dengue, 2020).

The COVID-19 pandemic has restricted travelling, trading, material supply networks, and even functioning of financial activities since late February 2020. Sri Lanka had to close almost all construction sites including both public and private sectors from the second week of March 2020 due to the pandemic situation. As the COVID-19 virus has adversely affected many industries including construction sector, it is extremely important to take necessary preventive actions to protect the construction industry from this pandemic virus (Health and Immunity Enhancement Guidelines for Covid-19 and Dengue, 2020).

Sri Lanka is a lower middle-income country with many infrastructure developments and there are number of major construction projects ongoing all over the country. Therefore, the study, in particular, is focused on analyzing the influence of the COVID-19 on the construction sector in Sri Lanka. Most recently, fewer research articles have analyzed the effect of the COVID-19 on the construction field in the global context. Moreover, the lack of literature on this study area encourages further research.

1.6 Methodology

As stated in the above, it is required to fulfill several objectives to achieve the aim of the research. Therefore, fulfilling objectives individually ultimately paves the way to reach the set target. A thorough literature survey was conducted to discover the available literature related to the impact of COVID-19 on the construction industry from different perspectives. In addition to that, the literature survey is extended to the methods where the research has to be carried out to investigate the impact of Covid-19 on the construction sector from different directions which would cover the four objectives of the research. The draft questionnaire is prepared through an in-depth analysis of the literature survey to achieve the required outcome of the objectives and a pilot survey was carried out to validate the draft questionnaire. The final questionnaire was developed using the Lime Survey Platform which was introduced by the University of Moratuwa. Therefore, survey participants were able to fill the questionnaire through an online platform and at the same time, data was saved in the university data base in digital format. To collect the data, the questionnaire survey was distributed among a sample of top and middle management levels of the construction sector. The purpose of the research is informed to the selected survey participants through the phone and questionnaire was e-mailed to each and every survey participant. The collected data was analyzed using Microsoft Excel and data

analysis software called Statistical Package for the Social Sciences (SPSS). The outcome would be discussed in detail for better recommendation and conclusion. All these outcomes while achieving these objectives pave the way to the accomplishment of the aim of the research.

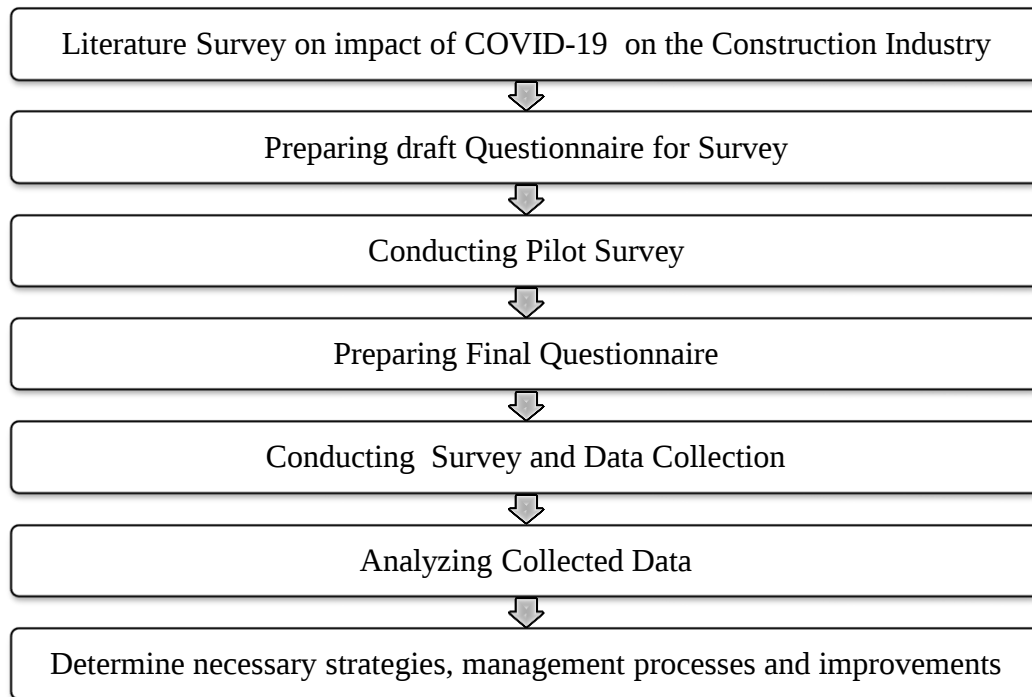


Figure 1.1: Research Methodology

1.7 Limitations of the Study

Even though, COVID-19 Pandemic has highly influenced several sectors in the country, this study is limited only for the construction industry as the pandemic has been having a significant impact on the Sri Lankan construction industry. Furthermore, the research is more focused on the workforce management inside the construction sites and dormitories. At the same time, this study aims to find out the effect of only the first wave of the COVID-19 Pandemic even though Sri Lanka has experienced and was significantly affected by the second wave of the pandemic. Due to this reason, during data collection, it was not possible to collect data conducting exploratory interviews and was unable to meet people physically because of the restrictions imposed by GOSL. Therefore, the data was collected through the online survey platform by emailing. As the construction industry consists of the workforces from different levels, the data collection was limited to the personnel who are from the top management and middle management levels. While

collecting the data through the online survey, the unwillingness of some personnel to participate in the survey was experienced.

1.8 Guide to the Report

For the easiness of the reference, this research will be divided into the following chapters.

Chapter 01: - This chapter provides the background for the research. It considers the aims, objectives, and research problems, scope of the research and its limitations.

Chapter 02: - This chapter provides the information obtained from the literature survey related to the effect of COVID-19 to the construction industry in the field of workforce management, safety, healthcare, and welfare facilities.

Chapter 03: - This chapter provides the information about the research methodology, and as the research designed by questionnaire survey research approach, the methods of data collection and data analysis are stated here.

Chapter 04: - This chapter provides the detail of quantitative and qualitative analysis of the collected data in the previous chapter and their findings.

Chapter 05: - This chapter discusses the results of the analysis and the limitations of the research.

Chapter 06: - This chapter provides the conclusions of the research study and recommendations derived from the research findings. In addition to that it is identified necessary strategies, management processes and improvements required for construction sites to successfully face any pandemic situations in the future.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1 Introduction

This literature review chapter demonstrates the theoretical works which have been carried out related to the impact of COVID-19 pandemic on different fields including the construction sector. This literature review simply summarizes the existing information and knowledge in the Sri Lankan context and international perspective.

The impact of COVID-19 on the economy and industrial sector worldwide have been studied and investigated by several researchers very recently. Because of the uncertainty of the current pandemic situation, the reviews are not yet adequate for a conclusion. Fernandes (2020) has studied about the influence of the pandemic outbreak on the economic sector of 30 countries. This research study has revealed that the Gross Domestic Product (GDP) got hit by 3-6% in most of the countries while in some countries, it has fallen up to 15% due to the spread of the pandemic. The study further outlined that the countries with service-oriented economies are negatively impacted from COVID-19.

Ayittey, Chiwero, Kamasah and Dzuvoor (2020) have studied and identified that most impacted sectors in the world are commerce, tourism, and trade. Another study carried out by Nicola et al. (2020) reported that the restrictions due to COVID-19 imposed by the authorities had reduced the movements affecting several industries causing them to shut down their businesses. Most of the employees have lost their jobs and the critical supply chains such as medical and food were interrupted. A study conducted by Ivanov (2020) has shown that the effect of the COVID-19 outbreaks on the material supply chain and found that it has been negatively impacted and further revealed that a considerable time might be taken to recover. Furthermore, a study conducted by Harari (2020) also mentioned that the COVID-19 pandemic may take years to recover from, and it is considered as the biggest pandemic crisis ever happened. In addition to that, he has explained that firm action must be taken to propose new strategies to prevent any pandemic situation in the future.

Helm, D. (2020) also explained that the total lockdown situations caused by COVID-19 has considerably limited the economic events and activities in many countries. However, any study concentrating on the influence of the COVID-19 pandemic on the construction industry has not been reported as of January 2021 even though this sector has been severely affected. Therefore, this research is mainly aimed at identifying the effects of COVID-19 on the construction industry in Sri Lanka.

2.2 History of Pandemic Situations in Sri Lanka

Sri Lanka is a developing country which faces epidemics periodically such as Dengue and Leptospirosis that cause several disease patients and a considerable number of deaths. Most of the countries in the world have experienced viral epidemics of respiratory illnesses recently such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). However, until COVID-19 was detected in Sri Lanka, Sri Lanka has escaped from major epidemic situations (Wickramaarachchi, Perera, & Jayasinghe, 2020). According to Drosten, et al. (2003), SARS and MERS viruses have caused two significant pandemic situations in the world recently. In addition to that, Zhou, et al. (2020) has mentioned that a new coronavirus (SARS-CoV -2) has initiated the COVID-19 epidemic situation in Wuhan, China on 12th December 2019 and it has confirmed that this arose from the coronavirus which was present in bats. The first Sri Lankan with COVID-19 virus was reported on the 10th of March 2020, and it has been continuously spreading everywhere in Sri Lanka (Roshana, Kaldeen, & Banu, Impact of Covid-19 outbreak on Sri Lanka Economy, 2020).

2.2.1 Overview of COVID-19 Pandemic

COVID-19 is identified as an infectious disease initiated from SARS-CoV-2 which is a strain of coronavirus from the SARS species. Initially, this virus was reported in Wuhan City, Hubei province, in China in December 2019. After that, it has been spreading very fast all over the world. The World Health Organization (WHO) has declared COVID-19 as a pandemic disease on 11th of March 2020 (Roshana, Kaldeen, & Banu, Impact of Covid-19 outbreak on Sri Lanka Economy, 2020). According to the study conducted by Li, Leung, Lau and Wong (2020), it was pointed out that patients who are more than 60 years of age have a higher risk while children have a lesser risk to become infected with the COVID-19 virus.

The COVID-19 pandemic in Sri Lanka started on 27th of January 2020 from a Chinese tourist. The first Sri Lankan COVID-19 patient, a tour guide was identified on the 11th of March 2020. Subsequently, the government of Sri Lanka announced immediate health measures understanding the potential spread of the disease over entire Sri Lanka. Accordingly, health and safety measures were implemented gradually such as closing offices and schools, travel restrictions, limiting public gatherings, shutting down airports and finally imposed the island wide curfew (<http://www.epid.gov.lk>, 2020).

Symptoms of COVID-19

COVID-19 (SARS-CoV-2) is able to create mild to severe illness. These symptoms consist of cough, fever, tiredness, shortness of breath and loss of taste or smell. Symptoms of COVID-19 will appear within a range between 2 days up to 14 days after contact with the COVID-19 virus (Health and Safety Guidelines for Sri Lankan Construction Sites to be adopted during COVID-19 outbreak, 2020).

Survival of COVID-19 Virus

It has been identified that when coughing or sneezing, the COVID-19 virus is widely spreading through droplets. The survival duration of the virus on different surfaces depends on the type of surface and it remains in air for approximately 03 hours (Health and Safety Guidelines for Sri Lankan Construction Sites to be adopted during COVID-19 outbreak, 2020).

Table 2.1: Survival Durations of Covid-19 virus on different surfaces

Type of Material	Remaining time Duration
Cardboard	03 hours
Copper	24 hours
Plastic	05 days
Paper	04 to 05 days
Wood	04 days
Glass	04 days
Aluminum	02 to 08 days

How COVID-19 Spreads among People

It has been discovered that the COVID-19 virus spreads mainly through person to person. The following modes are considered as main transmission methods of COVID-19.

- 1) Through the air and between people who are in close proximity.
- 2) Through the respiratory droplets from an infected person.
- 3) By touching a surface of objects with the virus.
- 4) By shoes or other personal belongings which are exposed to receive the virus.

It is considered that the COVID-19 virus can spread amongst all age groups from young to old. Furthermore, it could severely affect the people who are taking regular medicine for diabetes, kidney, cardiovascular disease, etc. (Health and Immunity Enhancement Guidelines for Covid-19 and Dengue, 2020).

2.2.2 Dengue Pandemic

Dengue is identified as a fast-emerging pandemic-prone virus-related disease in the world. The main vector that transmits the deadly virus is the Aedes Aegypti mosquito. Usually, dengue fever spreads rapidly in poor town areas and the rural area. As construction industry is significantly growing in Sri Lanka especially in urban cities in recent times, this has created several environmental and health concerns with plenty of mosquito breeding places in construction sites. As a result of that, dengue fever had an exponential increase in construction sites recently (Health and Immunity Enhancement Guidelines for Covid-19 and Dengue, 2020).

Avoiding bites by infected mosquitoes is the best way to prevent the disease. In addition to that self-protection and making attempts to keep the mosquito inhabitants down are also ways to reduce dengue virus. However, there is no vaccine available in Sri Lanka to prevent the dengue virus so far (Health and Immunity Enhancement Guidelines for Covid-19 and Dengue, 2020).

2.2.3 Vulnerability of Construction Industry for Pandemic situations

The nature of the construction sector is different from other industries. Construction workers usually have to work closely at sites, and they have to share construction tools and materials. Workers have to participate for pocket meetings daily and take common meals at dormitories. In addition to that, usually workers travel close to each other when using transport like trucks or buses. Therefore, for the construction workers, it is not possible to maintain social physical distancing and preventive measures (specified by the authorities) while working. Furthermore, many construction workers in Sri Lanka have bad habits such as consuming alcohol, chewing beetle and smoking etc. Due to all these and many more manners, the construction workers are at a high risk of getting infected from pandemics such as COVID-19 and Dengue. Hence, it is required to guide them appropriately to avoid getting infected from pandemic situations such as COVID-19 and Dengue (Health and Immunity Enhancement Guidelines for Covid-19 and Dengue, 2020).

2.3 Changes in Construction Industry due to COVID-19

Prior to the COVID-19 pandemic, construction works such as mixed developments, roads, apartments, hotels, restaurants, and shopping complexes were built rapidly as an ongoing process everywhere. The government encouraged the infrastructure development in urban cities because of ease of construction and cost saving. Furthermore, high-rise apartments were coming up in cities and there was a boom in the real estate market. In other words, the investments on infrastructure were on the increasing trend (The way forward after COVID-19, 2020).

The sudden lock-down imposed by the government due to the outbreak of the COVID-19 pandemic created a situation where the construction work forced to be shut down immediately. This situation brought the construction industry to a standstill. The work from home concept was in operation and some works associated with the construction industry were activated. Because of the COVID-19 threat, health directives enforced by the government requested the public and the workforce to stay indoors and to maintain a safe social and physical distance. The closure of shops, restaurants and service centers have forced the construction workers to return to their permanent residences or accommodations for safe staying (The way forward after COVID-19, 2020).

The government decided to lift the lock-down curfew situation after the 52- days lock down period (from 20th of March 2020 to 11th of May 2020) in Sri Lanka. However, the government has taken a number of steps to control the spread of the pandemic. Accordingly, restrictions for travel and transport were eased gradually with a lot of limitations. The COVID-19 situation created a considerable change in the construction industry, and it has modified the construction sequences and procedures at construction sites (The way forward after COVID-19, 2020).

After the COVID-19 pandemic, construction activities will rapidly grow as a number of projects will restart which have been delayed and halted for a long period due to the pandemic. However, construction methods and strategies will change as this is the post COVID-19 period. In addition to that, additional safety and health measures will be applied in the construction sites.

2.4 Effect of COVID-19 pandemic for Construction Sites

2.4.1 Workforce management

Araya (2020) stated that due to the COVID-19 pandemic situation, the management approach of construction workers in the construction industry is going to be changed and it should be developed from the traditional objectives. Therefore, the project managers of the construction industry have to incorporate their management strategies knowing how the COVID-19 pandemic may have an impact to the performance of the workforce and how to utilize the workforce effectively in different construction activities.

Most of the construction teams consist of different age groups such as young, middle aged and old. Furthermore, these workers are mostly from outstations and suburbs where people are much likely to have other illnesses, becoming more vulnerable to the COVID-19 pandemic. Most of the construction workers have a very low level of understanding on preventive measures and regulations. Therefore, there is a very high probability of workers getting infected without any symptoms and spreading the diseases in their workplace and dormitories. Therefore, the spreading of the virus among construction workers is significant and needs to be prevented with utmost care because an outbreak would destroy the Construction Industry and push the country into a dangerous situation (The way forward after COVID-19, 2020).

2.4.2 Health and Safety strategies

The COVID-19 pandemic situation has highly affected the health and safety strategies in the construction industry. In construction sites, Safety and Medical officers shall be suitably appointed to strictly monitor the workers whether they follow the safety and health instructions accordingly. Responsibilities of safety and medical officers have been changed with the COVID-19 pandemic situation. As per the GOSL instructions, the following health and safety strategies have to be implemented in construction sites to minimize the spread of the virus.

Table 2.2: Common Covid-19 Preventive Hygiene Practices at Construction Sites

	Health and safety strategies	How to implement
1.	Check Body Temperature	At the entrance of each construction site, body temperature of the workers should be checked daily, by a handheld equipment that can be used by maintaining social physical distancing.
2.	Washing Hands & Sanitization	At the entrance of each construction site, running water with soap and hand sanitizers are to be provided for the workers to wash their hands. Facilitation of hand washing, and frequent hand washing is mandatory.
3.	Personal Hygiene	Construction workers should avoid from touching their eyes, nose, face or mouth and they must refrain from sharing personnel belongings and construction equipment unless they are carefully sanitized. At all times during the outbreak and during the periods under observation, construction workers shall avoid mixing with crowds, keep away from crowded places and evade visiting public places.

2.4.3 Providing Welfare facilities

Welfare facilities are statutory procedures or social efforts designed to promote the basic physical and material wellbeing of people in need. Welfare facilities enhance the morale of the employees to work. Therefore, it improves the productivity and efficiency of the workforce and retain them for a longer period with the company. The main requirement of providing such welfare benefits to employees is to create a loyal, healthy, efficient, and motivated workforce for the company. In addition to that, welfare facilities provide a comfortable living condition for the workers and finally, it will improve their living standard (Gopalakrishnan & Brindha, 2017).

Workers play a significant role in any industry, and it is impossible to enhance the productivity and obtain higher turnover without the collaboration of the workers. Therefore, providing and arranging welfare facilities for the construction workers is an essential aspect which needs attention in construction sites especially under the pandemic situation. Gopalakrishnan and Brindha (2017) have further stated that welfare measures improve workers' health condition and increase their efficiency. The conditions of the workplace in the construction industry are different from the other industries. Construction sites are always movable and open places (locations) under direct sun. Welfare facilities required for construction workers are different than organized formal workers.

Welfare facilities for workers are considered as providing transport facilities, accommodation, sanitary facilities, lunchroom, and canteen arrangements, changing rooms and water facility. These welfare facilities needed a modification with the pandemic situation, and they should be well planned and organized to avoid spreading COVID-19 in construction sites while maintaining social distancing and minimum contacts. Therefore, responsible officers at construction sites have to implement best practice at sites and accommodation places as per the nature of the site (The way forward after COVID-19, 2020).

Table 2.3: Welfare facilities provided at Construction Sites

	Welfare facilities	How to provide the facility
1.	Transport Facilities	Providing transport facilities to workers and staff from the residence or accommodation places to the construction site and back by the company is a common welfare facility. If the construction site organizes site transport facilities, the workers have to maintain health and safety measures. Resorting to on-site or nearby accommodation is a favorable option to minimize risks of contacting COVID-19 while travelling.
2.	Accommodation Facilities	Most of the workers are provided with accommodation facilities at site premises or nearby the site location. There is a high chance of spreading the virus through bed linen, garments such as clothing, bed sheets, pillowcases, and other garments of workers. Therefore, the construction workers must refrain from sharing the garments and linen in their places of accommodation. Clothes and bed linen should be washed and dried by exposing to adequate heat or under direct sunlight.
3.	Sanitary Facilities	Sanitary facilities are important facilities considered under the welfare facilities for workers. Adequate sanitary facilities shall be provided in the worksite for workers such as lavatories, bathing rooms, changing rooms, etc. and they shall be disinfected regularly to reduce the spread of the COVID-19 virus.
4.	Lunchroom and Canteen Facilities	Providing lunchroom is another welfare facility for workers at sites. At each construction site, the lunch breaks should be staggered to ensure meaningful and successful implementation of the guidance given to avoid the spreading of COVID-19 due to possible lack of social physical distancing at canteens /lunchrooms. The number of persons using the lunchroom at any given time have to be minimized

		to ensure minimizing congestion and maintaining social physical distancing requirements.
5.	Changing Room Facilities	Workers' changing rooms at construction sites should always be kept clean and disinfected. Furthermore, hand washing must be facilitated at or near the changing rooms. To minimize the spread of the virus, personnel clothes of each worker should be kept individually. The furniture must be kept at a distance of one meter, and they must be cleaned and disinfected regularly. In addition to that, the number of people using changing rooms should be limited to prevent undesirable social physical distancing.

2.4.4 Preparing Construction Sites for Emergency and Disaster

An emergency is defined as a situation which harms or threatens individuals, property, or the ecosystem. It is impossible to totally remove the workplace emergencies. However, it can be mitigated through proper planning. Usually, emergency situations faced by the construction sector are considered as common for all construction sites. The main aim of emergency planning is to reduce the damages and losses due to emergencies. The workers in the construction sector are vulnerable to face various emergencies such as collapse of a structure, collapse of excavated side walls, scaffolding and tower cranes, fire, explosion, and pandemics, etc. Therefore, it is essential to establish proper emergency plans in the construction sites to be prepared to avoid and handle emergencies. Furthermore, the emergency preparation plan should include how to respond to an emergency while recognizing possible emergencies in construction sites (Raja Prasad & Prasad Rao, 2012).

The construction sector is considered as a vulnerable industry for natural disasters as well as manmade disasters and it might be a direct threat to workers. For an instance, high-rise building construction projects are more critical as thousands of workers who work on the different floors of the structure required to be evacuated within a short time period in an emergency case. Therefore, it is essential to establish proper emergency action plans and emergency evacuation procedures at construction sites. In addition to that, regular escape assignments have to be conducted following occupational safety regulations. Usually while operating real life drills, these emergency escape plans are assessed and used for training the workers. However, these emergency evacuation routines face critical

challenges practically in construction sites as it totally changes the usual environment of a construction site, especially in high-rise building construction projects (Said, Kandil, & Cai, 2012). As per the study carried out by McEntire (2015), it has been mentioned that the emergency planning process includes four cyclic phases such as (1) prevention, (2) preparedness, (3) response and (4) recovery.

Preparing for emergency pandemic situations is different from the general construction site emergencies. Therefore, it is very important for each construction site to plan to establish an emergency plan to face any pandemic situations. For instance, identification of a COVID-19 suspect case alone is considered as a state of emergency within a construction site. Therefore, appropriate emergency action has to be taken immediately for the suspected patient as a measure to avoid the spreading of COVID-19.

Health and Immunity Enhancement Guidelines for COVID-19 and Dengue (2020) have elaborated the following preliminaries to be considered as essential for successful handling of an emergency pandemic situation,

1. Nominating a Safety and Occupational Health officer/supervisor.
2. Maintain a designated first aid room and an isolation room.
3. Maintain a register of deployed workforce with details.
4. Displaying notice to follow the procedure at an emergency.
5. Maintain a registry with personnel health information of each employee.
6. Regular monitoring and tracking workers.
7. Regularly training workers to act in an emergency.

2.4.5 Changes of Construction Methods with Covid-19 Pandemic

The way forward after COVID-19 (2020) stated that construction methods have been improved in Sri Lanka's construction industry with time. Globally, a wide variety of modern construction methods have been developed and used at an increased rate. However, the present methods used in Sri Lanka are mostly manual and traditional. The manual systems practiced in the construction industry require personnel to work in close proximity. The facilitation and compliance of health regulations while maintaining the required productivity to deliver targets, has become a challenge for the construction industry. Accordingly, after COVID-19 pandemic, the world requires the construction industry to change its methods to use less manpower to become more productive and to turn out to be environmentally friendly.

2.5 Hierarchy of Control Measures in Construction Sites

The construction sector is considered as one of the most hazardous industries because of the risks engaged in the construction processes and activities. Establishing occupational health and safety practices is identified as a major problem in the construction industry. A number of different construction activities are carried out in a construction project. According to the method of construction, health and safety risks and control measures relevant to each construction activity varies (Uzun, Bilir, & Cebi, 2018).

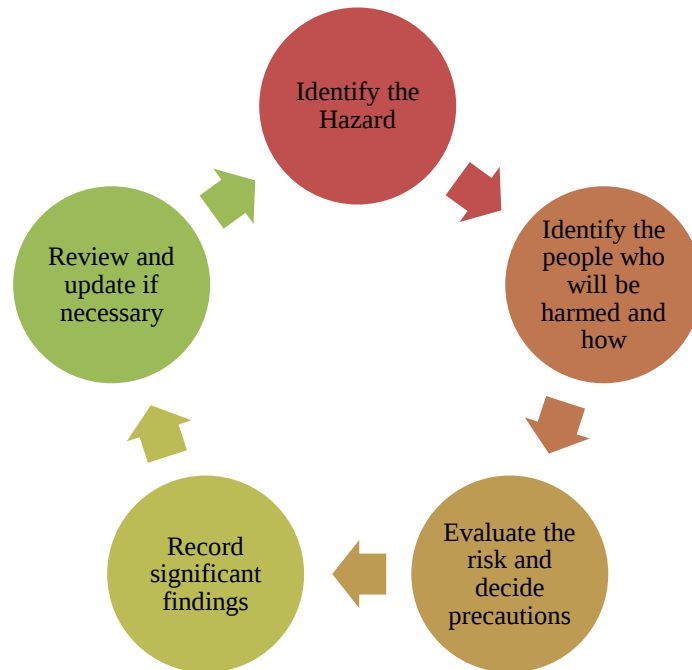


Figure 2.1: Process of Risk Assessment (Uzun, Bilir, & Cebi, 2018)

Risk analysis and evaluation of the actions are considered as the main elements of the Occupational Health and Safety activities. The main steps of risk analysis in construction sites are as shown in Figure 2.1. Once the analysis is completed, the required control measures have to be taken to prevent hazards. The risk control hierarchy can be used to decide the most suitable control measures to minimize the risk or prevent the hazard.

Risk Control Hierarchy

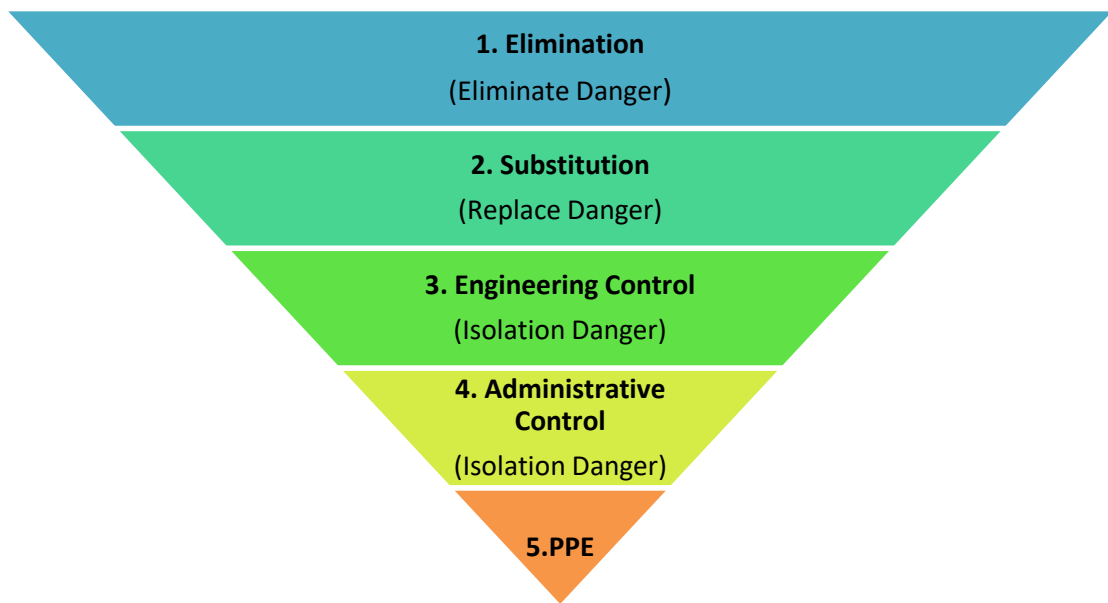


Figure 2.2: Hierarchy of Controls (Uzun, Bilir, & Cebi, 2018)

As shown in the Figure 2.2, elimination and substitution are the initial method of mitigation of risks. Next steps can be identified as engineering and administrative controls and finally it will end with personal protective equipment (PPE). Nevertheless, most of the construction sites concentrate on engineering controls and use of PPE's.

2.6 Summary

This chapter has provided an in-depth and comprehensive understanding of the published primary and secondary literature related to theoretical, methodological and conceptual discussions and studies done at a global and local level on the effect of COVID-19 pandemic for different industries including the construction sector. The literature examined in this chapter on theory and concepts were primarily useful in identifying the concepts that would ground this study while the discussion on methodological tools provided the basis for identifying the most appropriate methods and techniques for questionnaire development, data collection, data analysis and interpretation of the findings of the study. The literature also highlights the importance of studying effect of the COVID-19 pandemic for the construction industry.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

Research methodology implemented for this study will be described in detail under this chapter. At the beginning of this chapter, the research process and the research design will be discussed. The questionnaire development process with a pilot survey will be further discussed together with a description of the sample selected for the study and the process of the collection of data.

3.1 Introduction

The research methodology describes the research methods and techniques used in the research. The data for the study needs to be straightforward and accurate to fulfill the objectives of the research. This chapter will elaborate the processes of data collection for the research. This survey attempts to explore the influence of the COVID-19 pandemic to different areas of the construction sector in Sri Lanka. The literature survey and the information gathered from the sources were the basis to get a deep understanding of the impact of COVID-19 for the construction sector in different ways. In addition to that, the literature survey has been extended to the methods where the research has been conducted to explore the impact of COVID-19 for the construction sites in different directions which will cover the four objectives mentioned in the Research Objectives under Chapter 01.

3.2 Research Process

3.2.1 Literature Review

While keeping the focus on the objectives of the research, the literature survey was expanded progressively. The literature survey was carried out to investigate the impact of the COVID-19 pandemic on the construction industry by incorporating gaps in this area, different concepts, definitions, techniques and verifying the significance of the research problem. The literature search was conducted referring publications such as journal articles available in academic databases, thesis, books, and conference papers from the university library. Finally, the literature survey was completed including required depth, consistency, clearness, and efficient analysis for the research study.

3.2.2. Research Problem Statement

To achieve the research objective, the background study was carried out and identified the available methods for analyzing the effect of the pandemic for different areas of the construction industry. The global pandemic situation of COVID-19 has generated a severe impact on the construction industry creating many economic problems worldwide. The coronavirus has altered the global demand for the construction industry as many countries are concentrating more on giving support to the shrinking economic sectors. The construction industry of Sri Lanka plays a significant role of the country's economy. In Sri Lanka, the construction industry is slackened because of the island wide lockdown (52 days) imposed by the Government of Sri Lanka (GOSL) which restricted all movements. As a result of that, the construction sector was severely affected from this COVID-19 Pandemic.

However, many construction companies have reduced their workforce to control the pandemic situation in construction sites. The new safety guidelines, practices and regulations limit the construction industry to operate under normal conditions, this global pandemic has already changed the conventional methods and practices of the construction industry limiting and restricting the opportunities and developing new challenges. Therefore, it is essential to study and analyze the ways to face any pandemic situation in the future successfully.

3.2.3 Application of Survey Methods for the Research

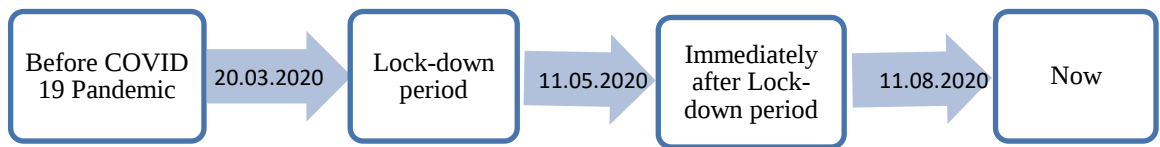
Survey methods are widely used by many researchers as they allow to collect a large amount of data from a selected population with consuming less time and in an economical way. Usually, the required information is collected using a well-designed questionnaire forwarded to a selected sample and finally, these data are standardized for comparison. Furthermore, this survey strategy is simple and comparatively easy to explain or understand. Through this method, the researcher can analyze collected data quantitatively using descriptive and inferential statistics easily.

3.2.4 Questionnaire Development

The questionnaire survey is considered as a popular data collection technique used in the world. The detailed questionnaire survey was the most important part of this data collection. Using this data collection technique, responses can be collected efficiently and accurately from a large sample before conducting the quantitative analysis. In the

questionnaire survey, a similar set of questions are given to respondents and requested to answer. In this research, the Questionnaire Survey was carried out in order to achieve the objectives of the research and most of the questions in the questionnaire have been rated in a Likert scale. The questionnaire consisted of the five main sections such as (1) General Information, (2) Workforce Management, (3) Health and Safety Strategies, (4) Welfare Facilities, (5) Preparation for Emergency and Disaster. Furthermore, the questionnaire was designed to collect the information during different time phases to compare the effect of COVID-19. The selected time phases are defined as follows.

Table 3.1: Time phases used to collect data for the Questionnaire Survey



In the questionnaire development, the Likert scale has been used for most of the questions to get answers. A psychometric scale is used in the Likert scale, and it has multiple categories to choose for respondents to express their opinions or feelings about a particular issue. Using a Likert-scale questionnaire, data can be collected quickly from large numbers of respondents.

Pilot survey 01

The main objective of the pilot survey was to validate and prepare the detailed questionnaire in a consistent manner to achieve objectives successfully. The first pilot survey was carried out with a sample group of five respondents, (1) to verify the appropriateness of the questions to the larger research population, (2) to rule out any incompatible results, (3) to have a clear view of the outlines of the research, and (4) to ensure the effectiveness of the type of survey selected for the study. Accordingly, five selected respondents were given the draft questionnaire to fulfill the above-mentioned requirements. A semi-structured questionnaire was developed for the Pilot survey 01 using google sheet and circulated through e-mails to the selected sample of five respondents. This draft questionnaire was structured with five sections including general information and four other relevant sectors which were identified through the literature survey, and it consisted of a total of seventy (70) questions to fulfill the objectives of the

research. The results of the pilot survey 01 revealed that number of questions were too much, and it takes 40min to answer all questions and some of the answers to the questionnaire were not consistent. It was identified that the reason as the questions were not structured properly, and some of the questions were too long to read and answer. Therefore, the questions needed to be re-structured based on the outcomes of the pilot survey.

Pilot survey 02

As per the outcomes of the pilot survey 01, the structure of the questionnaire was updated blending similar types of questions. In this case, it was realized that Google sheet was not supporting to restructure the questions as it had less options for modifying of the questions. Therefore, the questionnaire was developed using the Lime Survey Platform which is operated through the university data base. Finally, the restructured questionnaires consisted of 46 questions. Pilot survey 02 was conducted again for five number of known people through emails. The average time taken to answer the questionnaire was reduced to 20 minutes. The outcome of the pilot survey 02 indicated that some answers and answering options needed to be simplified to make it less time consuming to the respondents.

3.2.5 Data Collection

Sampling

Sampling can be defined as the method of selecting a representative sample from a population. However, selecting the most appropriate sample for the study is quite difficult (Tan W. , 2002). In the case of this research, sampling was done using the information collected by the pilot survey. Therefore, the “convenience sampling” method was used to gather the data, as accessibility and cooperation was the major consideration in the phase of data collection with the impact of COVID-19. The number of construction sites were selected to cover all areas in Sri Lanka. Furthermore, the data has been collected only from the top management and middle management level staff of the construction sites.

Final Questionnaire survey

As per the outcomes of the pilot survey 02, the responding preferences and method of answering the questionnaire was updated and simplified. The final questionnaire was circulated through email invitations of participants who are in the top management level and middle management level at various construction sites island wide. The convenience sampling method was used for selecting the sample and the data was collected within two months (01.10.2020 to 31.11.2020). Finally, seventy-three (73) numbers of fully completed responses were received for the questionnaire survey.

3.2.6 Data Analysis

Quantitative Data Analysis

Research objectives were accomplished evaluating the collected data through the questionnaire survey. The quantitative data analysis method was used to transform raw data into a meaningful and useful data. Quantitative data can be identified as the value of information in the form of numbers and each data is associated with a unique numerical value. This quantifiable information is used for mathematical computations and statistical analysis (Uma Sekaran, 2003).

Data Analysis Platform

Most of the questions in the questionnaire have been using a 5-point Likert scale. One of the most important parts in a research project is the data analysis. The platform of data analysis acts as a significant role for accuracy and output of the research study. The Statistical Package for the Social Sciences (SPSS) and Microsoft Excel software platforms were mainly used for data analysis. SPSS software provides a number of advantages for data analysis. Advanced statistical analysis can be performed using SPSS software and, text analysis is available in SPSS.

3.3 Summary

This chapter discusses the methodology and the design of this research. The survey method has been figured out as the best research approach for this research study. The questionnaire survey method is considered as the best method to collect data from different construction projects during the COVID-19 pandemic situation. Two pilot surveys have been conducted before finalizing the final questionnaire in order to achieve the objectives of the research. The questionnaire was designed to collect the information during different time phases to compare the effects of COVID-19 and the final data was collected through an online survey platform. In addition to that, research design and data analysis procedures have been presented by this chapter. The Statistical Package for the Social Sciences (SPSS) and Microsoft Excel software platforms were mainly used for data analysis.

CHAPTER FOUR

4.0. ANALYSIS AND RESULTS

4.1 Introduction

The data collection and analytical techniques were described under the chapters for Introduction and Research Methodology. Accordingly, desktop research was conducted to find out the present knowledge on the effects of Covid-19 Pandemic for the Construction industry in Sri Lanka and in the world. Based on that, four (4) main significant sectors in the construction industry were identified for further study. They are (1) Workforce Management, (2) Health and Safety Strategies, (3) Welfare Facilities, (4) Preparation for Emergency and Disasters. Finally, the identified four main areas were included in the questionnaire. The final questionnaire was developed using the Lime Survey Platform to collect data online.

4.2 Data Analysis

4.2.1 General Information of Respondents

In order to get a better understanding about the respondents, the first section of the questionnaire consisted of general questions on the demographic background of the respondents. It was designed to explore the general information of respondents and the companies such as Company types, Job roles, Current grades of the companies, the type of construction involved, and the number of projects handled by the companies. The collected data was summarized as follows.

Company Type

Figure 4.1 depicted the general information collected during the survey. The majority of respondents were from private sector construction companies (33, 47.14%) while an equal number of respondents were from government and semi-government companies (16, 22.86%) in second place. Only 4 respondents (5.71%) from foreign construction companies have participated in the survey.

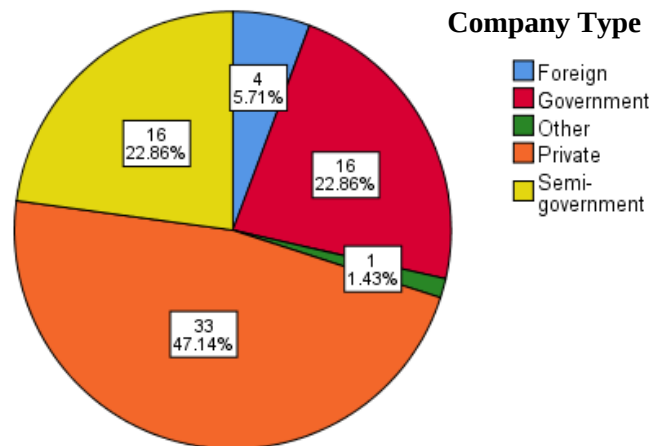


Figure 4.1: Cross Section of respondents (Company type)

Job role

Figure 4.2 elaborates that most of the respondents are from main contractors (29 out of 73) when it comes to the job role.

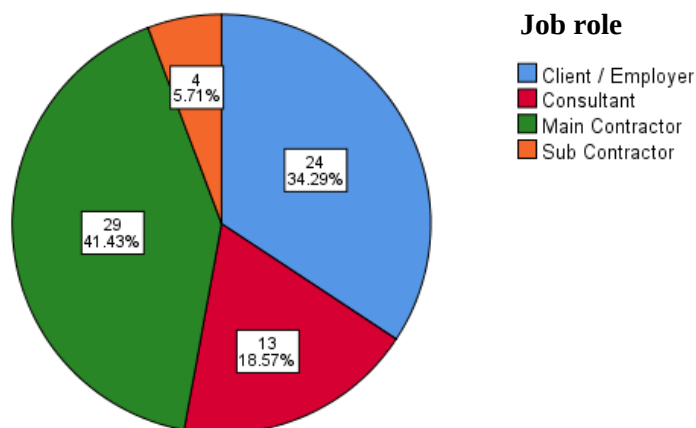


Figure 4.2: Cross Section of respondents (Job Role)

Current Grade of the companies

Figure 4.3 indicates that most of the construction companies of respondents (17 out of 73) are categorized under the C1 type according to the grading system developed by the CIDA. Despite the given grading, a considerable number of respondents (16 out of 73) have marked their companies under the other types.

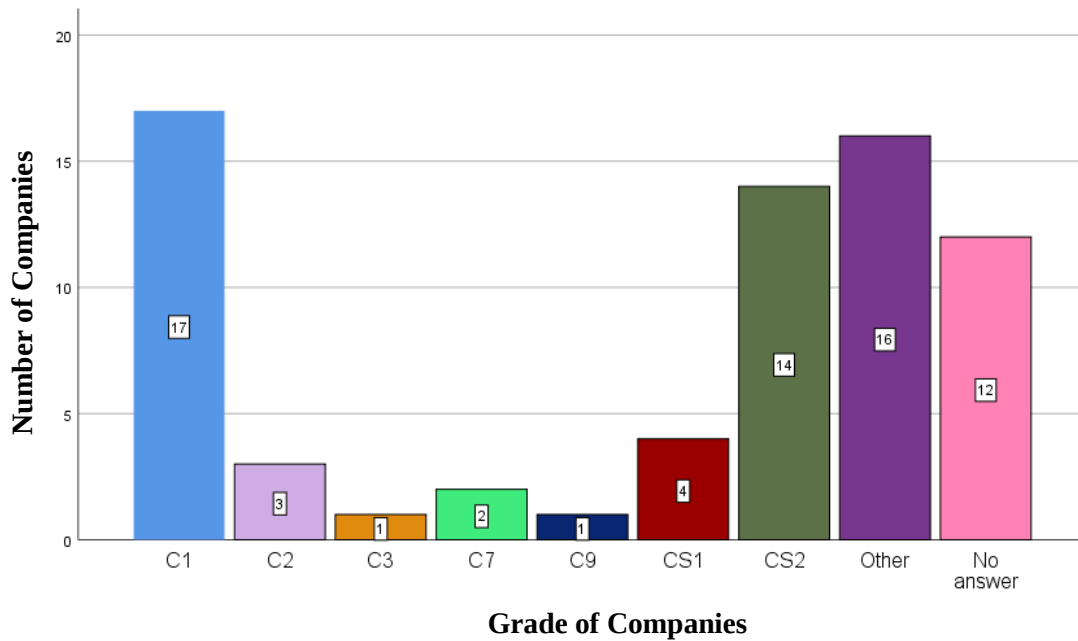


Figure 4.3: Cross Section of respondents (Company Grade)

Number of Projects handled by the Company

As shown in Figure 4.4, the number of ongoing construction projects handled by respondents' companies have experienced a significant drop during the lockdown period. However, immediately after the lockdown period, the number of projects have started to rise again gradually evidencing that construction companies have started to recover from the disruption of the pandemic.



Figure 4.4: Number of construction project handle by the companies

Number of fully Lockdown Days

Table 4.1: Number of days the construction sites were fully locked-down

Fully lockdown days	N	Minimum	Maximum	Mean	Std. Deviation
	70	0	180	52.13	30.617

As per the Table 4.1, construction companies have been closed for a period of zero to 180 days. Based on the mean value of the data set, it can be calculated that construction sites were under lockdown for approximately 52 days.

4.2.2 Workforce Management

It is projected that the management approach of construction workers in the construction industry will be transformed with the impact of COVID-19. It has called for the need for exploring on how the COVID-19 pandemic may have an impact on the performance of the workforce and how to utilize the workforce effectively in different construction activities.

4.2.2.1 Workforce Composition

Results of the questionnaire survey indicate that the number of local laborers and staff members of construction companies have experienced a significant drop during the lockdown period compared to the number of foreign laborers and staff members. This decision has been taken by construction project managers to create a safe working environment for workers while minimizing the chances of getting infected with COVID-19. However, the total workforce has started to increase smoothly after the lockdown period. Although there was a cut down in the size of the workforce, the majority of companies were not planning on changing the size of the workforce. But as shown in Figure 4.5, a trend can be seen towards reducing the number of foreign workers and recruiting more local laborers in the future.

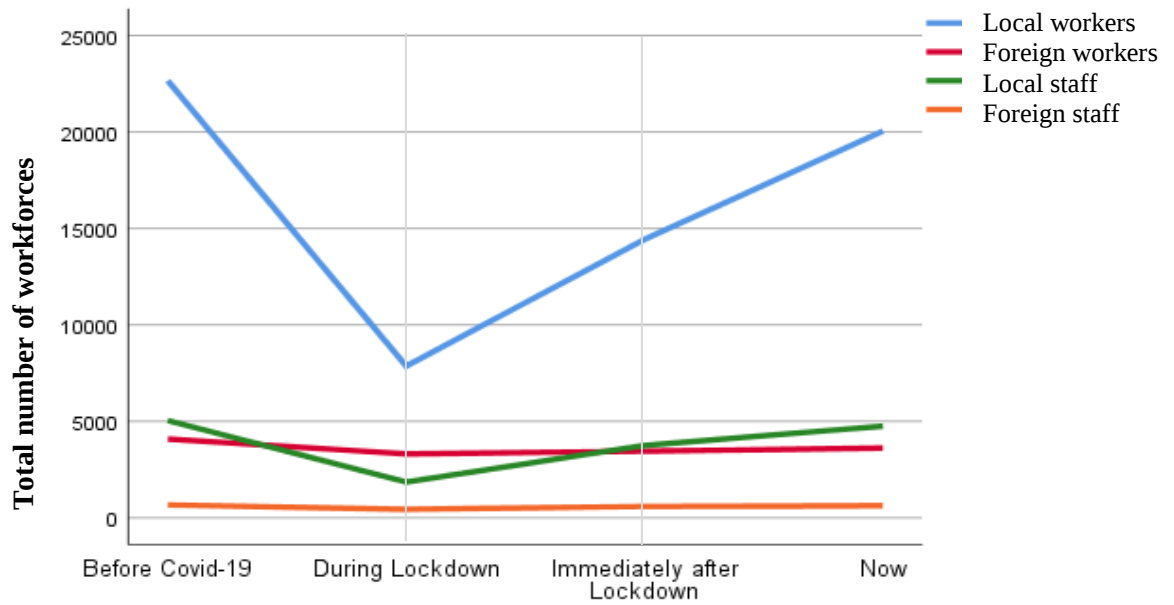


Figure 4.5: Workforce composition in construction sites

However, Figure 4.6 stressed that most of the companies are not planning to change the workforce composition for both locals and foreigners in the future. However, the companies that are planning to increase the workforce in the future are mostly for locals while the companies that are planning to decrease the workforce in future are mostly for foreigners.

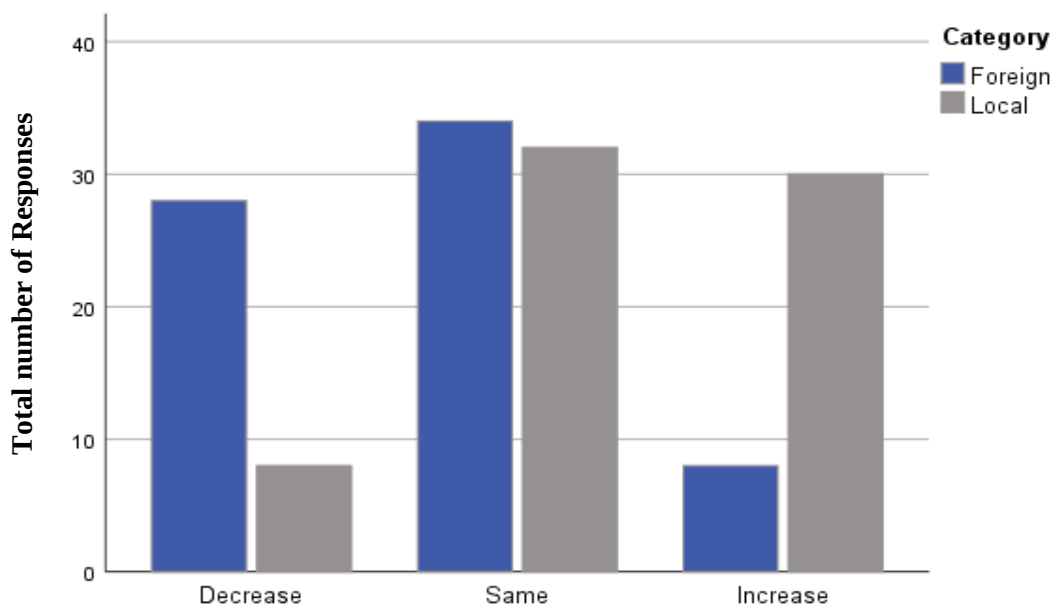


Figure 4.6: Planning to Change the workforce composition in future

4.2.2.2 Difference between Local and Foreign Workforce

Since there is a major concern about the difference in the productivity of foreign and local laborers, a Likert scale was used to acquire responses on the level of satisfaction of the performance of both types of laborers. To determine the satisfaction level of the workforce, it has been considered the level of Efficiency, Confidence, Attitude, Reliability, Productivity, Communication skills, Teamwork and Leadership of foreign and local workers. Based on the received responses the highest mean value of the satisfaction level of the workforce has been obtained by foreign laborers while keeping a small standard deviation when it is compared with local laborers. The Figure 4.7 through box plots illustrate that the difference between local and foreign workforce in line with the above results.

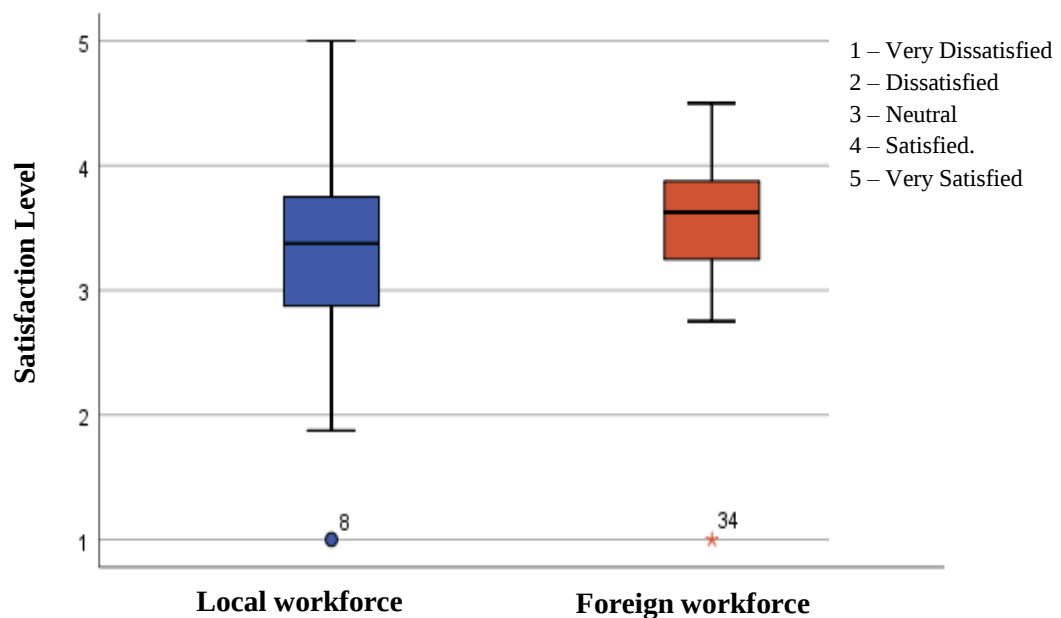


Figure 4.7: Difference between local and foreign workforce

4.2.2.3 Standard working hours and Over time works.

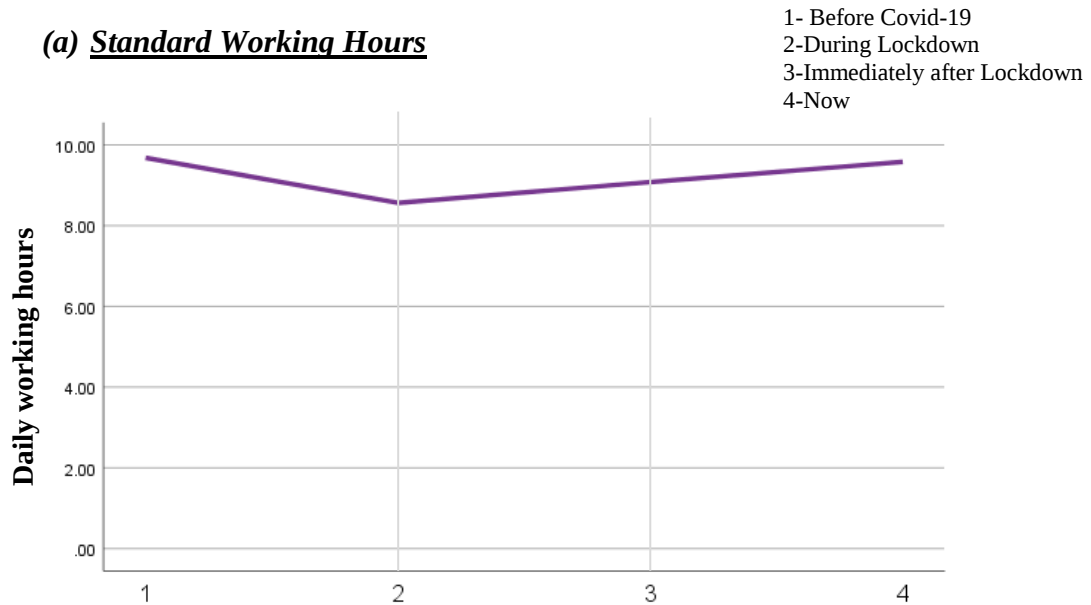


Figure 4.8: Fluctuations of standard working hours in construction sites

As per the Figure 4.8, average standard working hours in construction sites has been reduced during the lockdown period and it has again started to increase gradually immediately after the lockdown period.

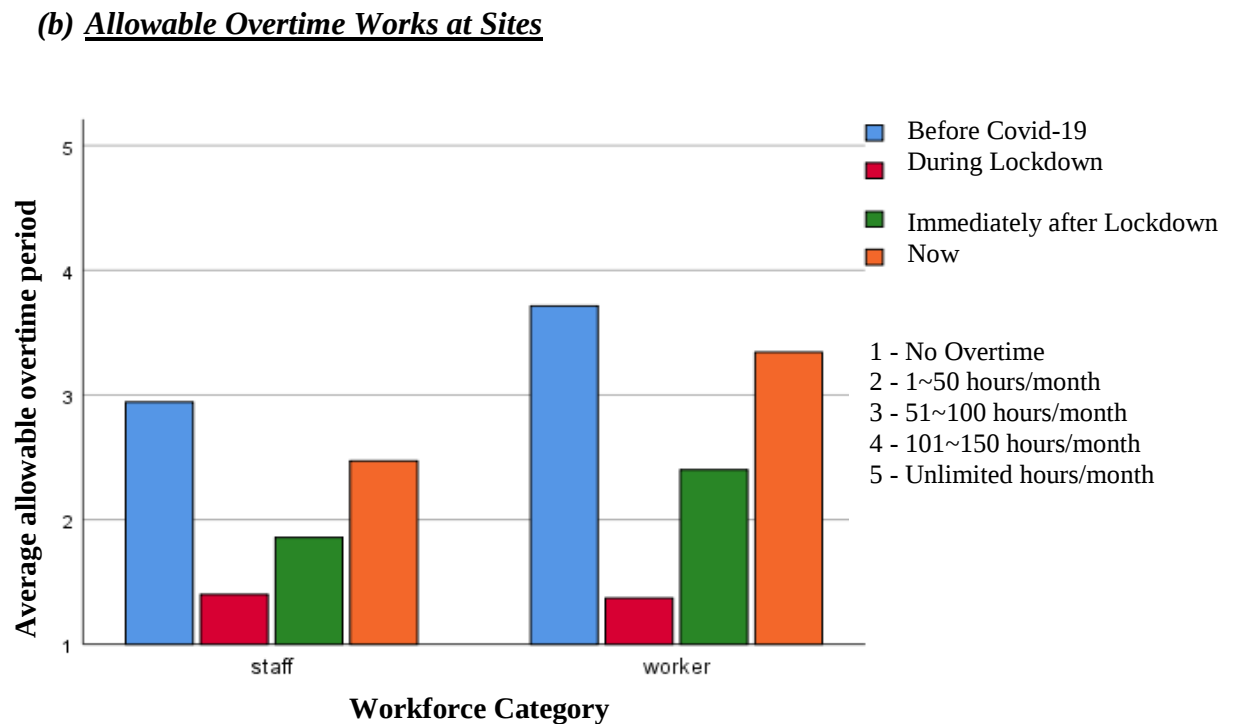


Figure 4.9: Allowable overtime works for workers and staff

Figure 4.9 indicates that the average allowable overtime hours for workers and staff have been considerably reduced during the lockdown period and it has again started to increase gradually immediately after the lockdown period for both workers and staff. However, the allowable overtime period for workers is comparatively higher than the staff all the time.

4.2.2.4 Paying salary for workers and staff

According to Figure 4.10, the percentage of average payment of salary for workers and staff has been reduced during the lockdown period and it has again started to increase immediately after the lockdown period. However, the percentage of payment of the salary for workers during the lockdown period was higher compared to the staff in the same time duration.

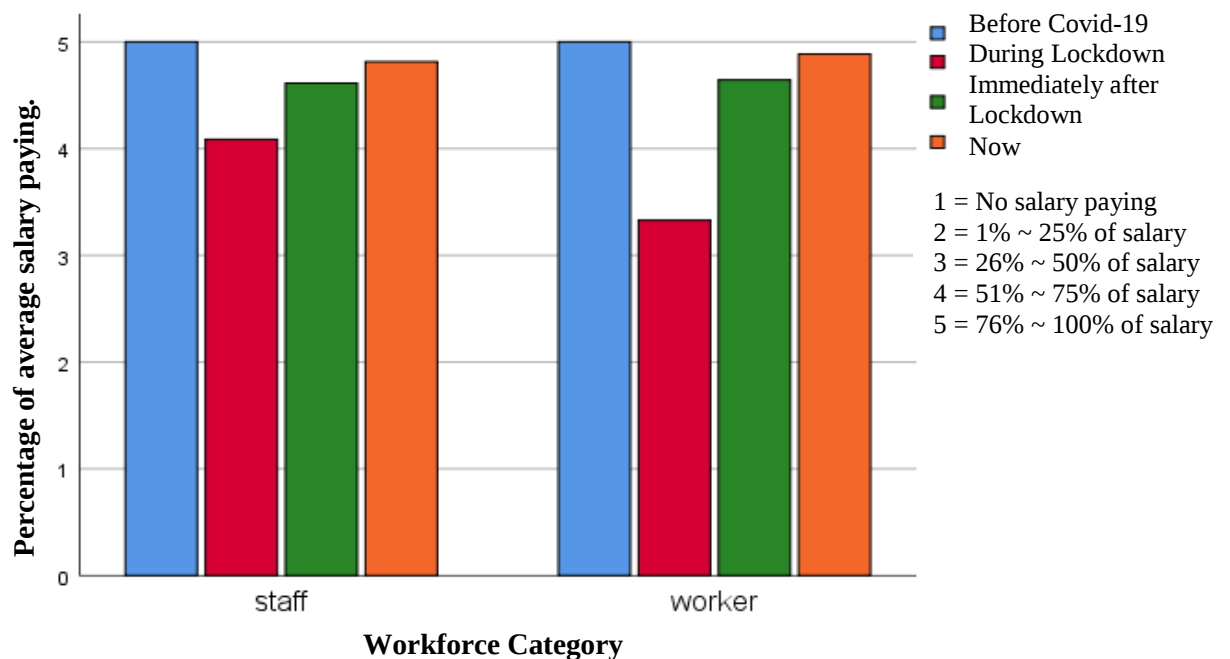


Figure 4.10: Paying salary for workers and staff

4.2.2.5 Reducing workforce during lockdown period

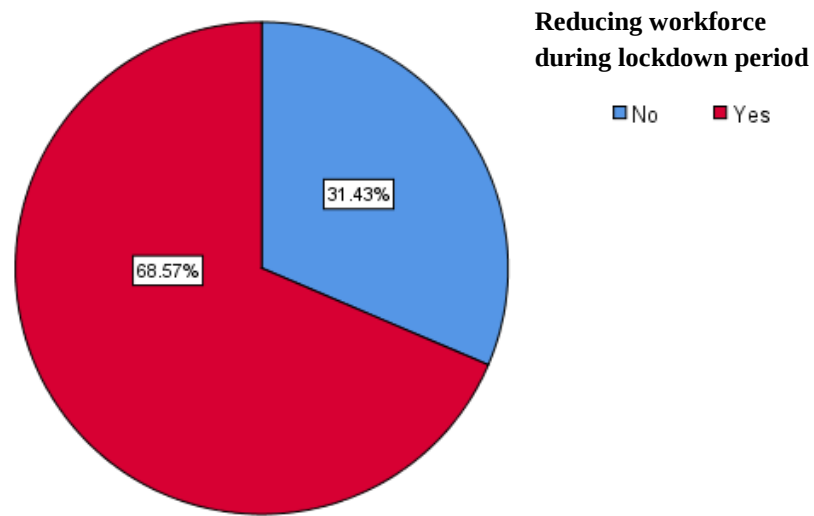


Figure 4.11: Reducing workforce during lockdown period

Figure 4.11 shows that more than 68% of respondents have stated that the workforce in their construction sites was reduced during the lockdown period. Therefore, COVID-19 situation has significantly affected the workforce of the construction sites.

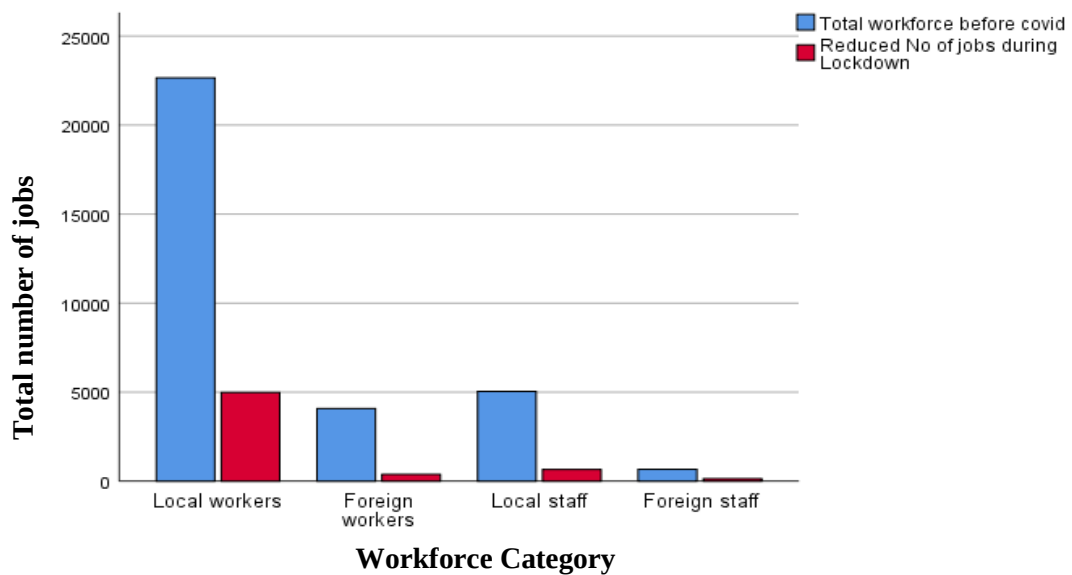


Figure 4.12: Number of jobs reduced during lockdown period

Furthermore, Figure 4.12 indicates that most of the local workers have lost their job opportunities during the lockdown period compared to the situation before the COVID-19 pandemic. However, foreigners have not lost many jobs compared to locals.

Subsequent Action taken by reduced foreign workforce

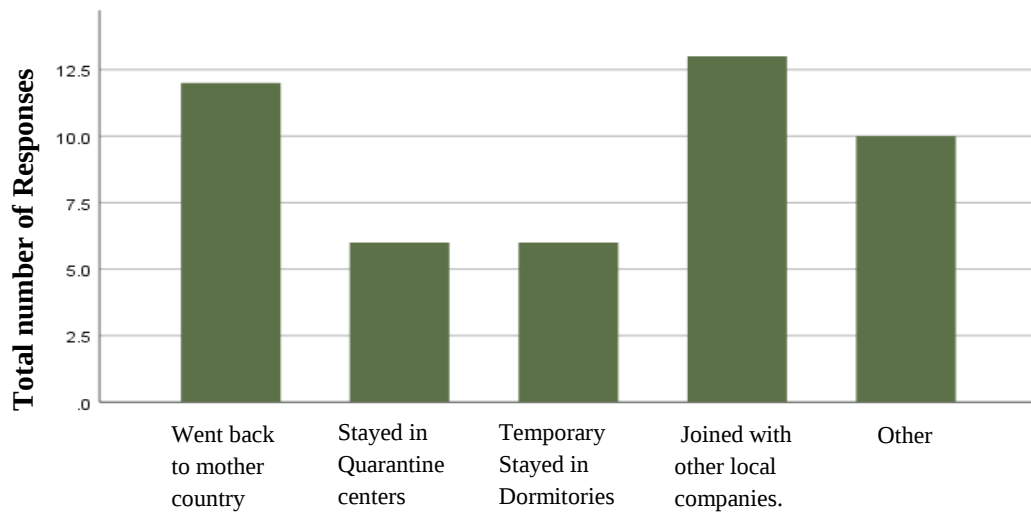


Figure 4.13: Subsequent actions taken by the reduced foreign workforce

According to Figure 4.13, most of the reduced foreign workforce due to the COVID-19 pandemic had to fly back to their mother country and have joined with other local companies.

4.2.2.6 Factors for selecting workers/staff to Terminate Jobs

The survey has focused on factors that affect decisions on terminating jobs of laborers and calling them back to work. Six factors were suggested in the survey and respondents were asked to rank them on the Likert scale. According to the results of the survey, the following factors were considered in terminating the jobs of laborers.

1. Level of performance
2. Health conditions
3. Age limit
4. Working experience

Basic salary and distance from home to sites were not much considered in terminating jobs.

Basic Salary

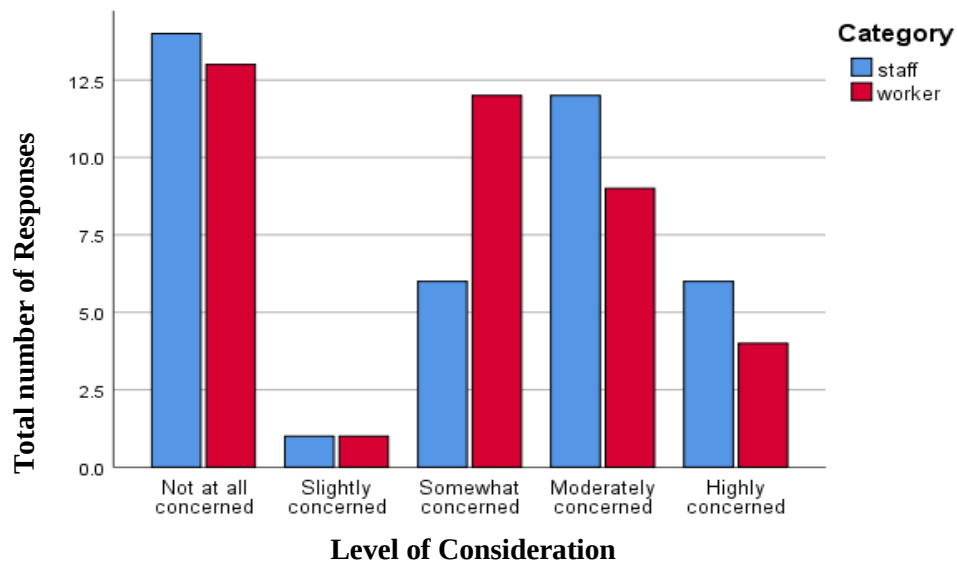


Figure 4.14: Consideration of Basic Salary to terminate jobs

Basic salary had not been considered most of the time when terminating jobs of workers or staff in construction sites.

Performance

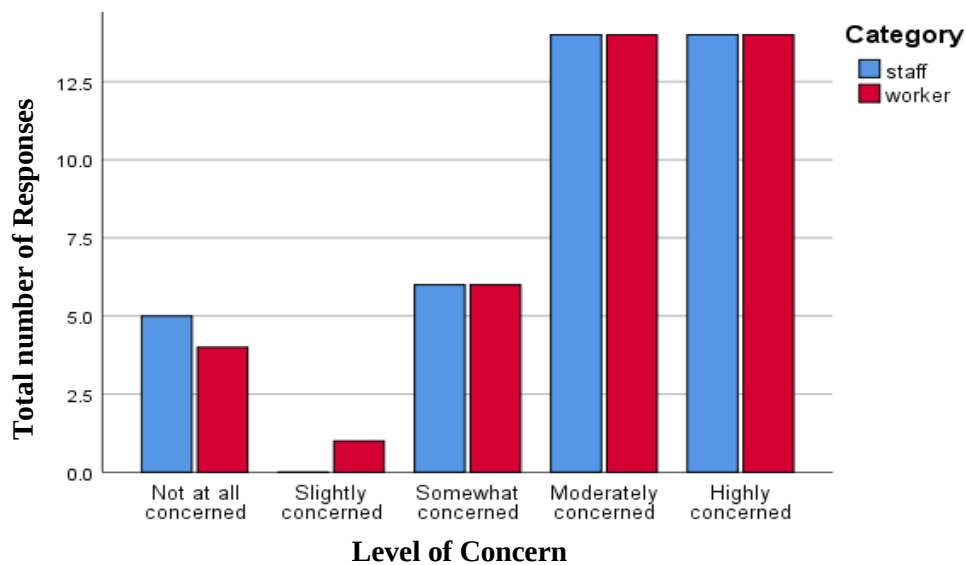


Figure 4.15: Consideration of Performance to terminate jobs

Performance had been highly considered when terminating jobs of workers and staff in construction sites.

Health Condition

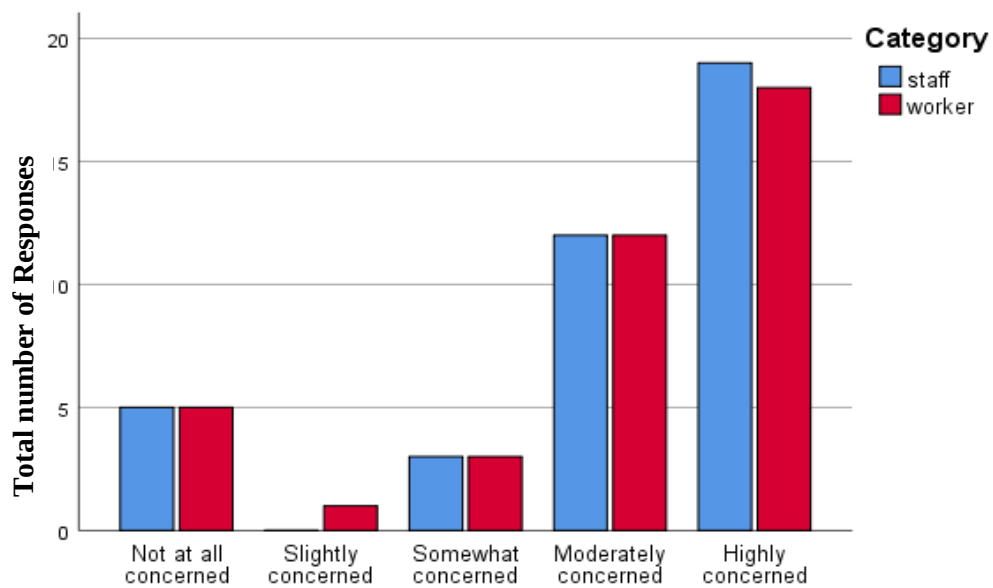


Figure 4.16: Consideration of Health Condition to terminate jobs

The health condition had been highly considered when terminating jobs of workers and staff in construction sites.

Age Level

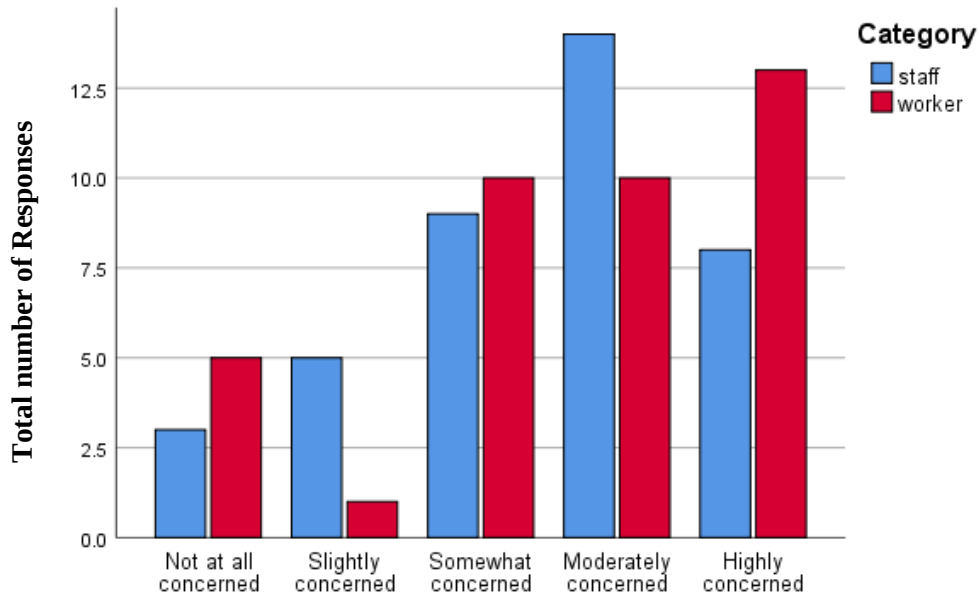


Figure 4.17: Consideration of age limit to terminate jobs

The age of workers had been highly considered when terminating their jobs. Workers have to engage in physical activities at construction sites and they should be strong enough to work hard. This might be the reason behind this result. However, age of staff had moderately been considered most of the time for terminating their jobs.

Working Experience

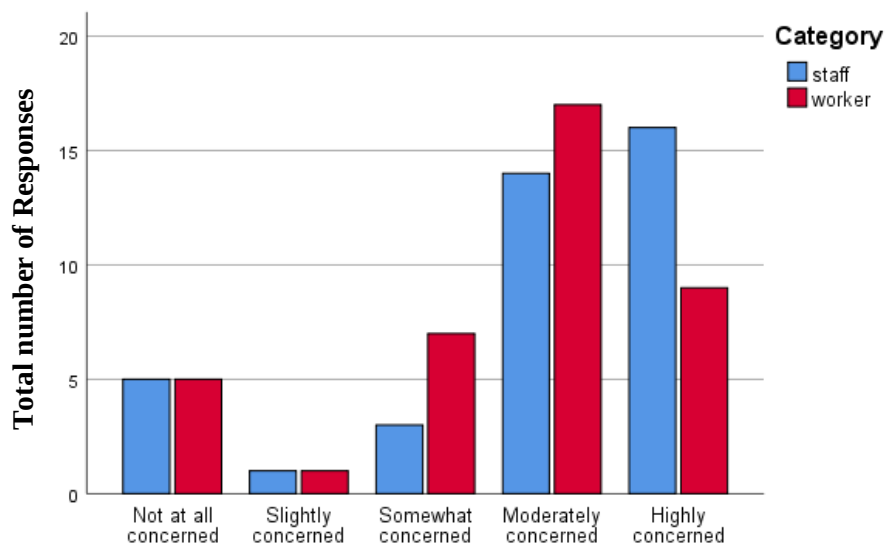


Figure 4.18: Consideration of working experience to terminate jobs

The amount of experience had been highly considered when terminating jobs of both workers and staff in construction sites. It is a well-known fact that it is better to keep experienced employees in any field.

Nationality

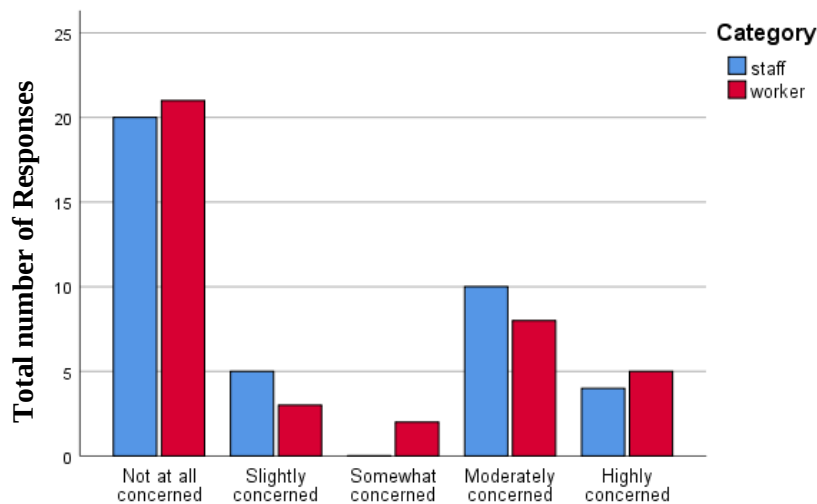


Figure 4.19: Consideration of Nationality to terminate jobs

Nationality of workers and staff had not been considered most of the time when terminating their jobs since it did not affect the performance.

Distance from Home

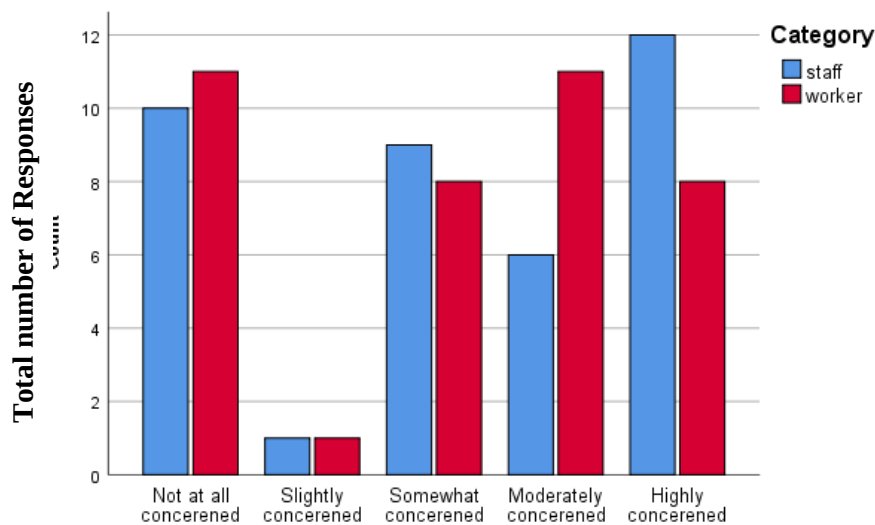


Figure 4.20: Consideration of ‘distance from home’ to terminate jobs

It is hard to obtain a clear conclusion regarding the concern on the ‘distance to the workplace from home’ when terminating jobs of workers and staff. While some companies highly considered the above facts and other companies did not, it completely depends on the company management and the site locations.

4.2.2.7 Factors considered when selecting workers/staff for calling back

According to the results of the survey, the following factors were considered when calling laborers back to work.

1. Level of performance
2. Health conditions
3. Age limit
4. Work experience
5. Distance from home

In addition to the factors considered in terminating jobs of laborers during the lockdown period, the distance from the home of laborers to the site was taken as a factor in calling back to the job. These factors suggest that retaining the optimum size of the labour crew with maximum productivity and minimizing the contact of laborers with outsiders have become a major concern in terminating jobs and recruiting laborers back to work.

Basic Salary

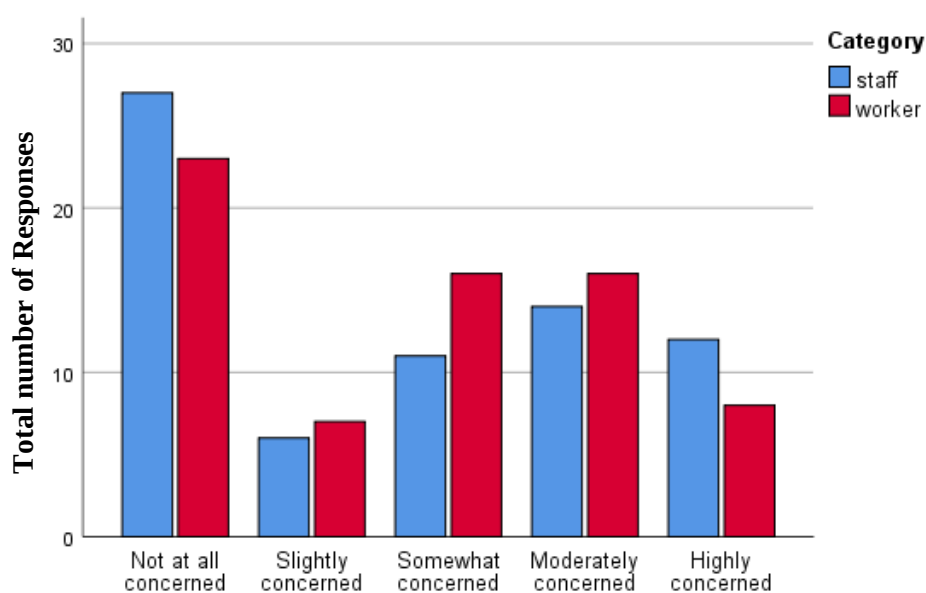


Figure 4.21: Consideration of Basic Salary for calling back to work

When selecting staff and workers for calling to report back to work immediately after the COVID-19 pandemic, most of the time the basic salary was not considered for both categories.

Performance

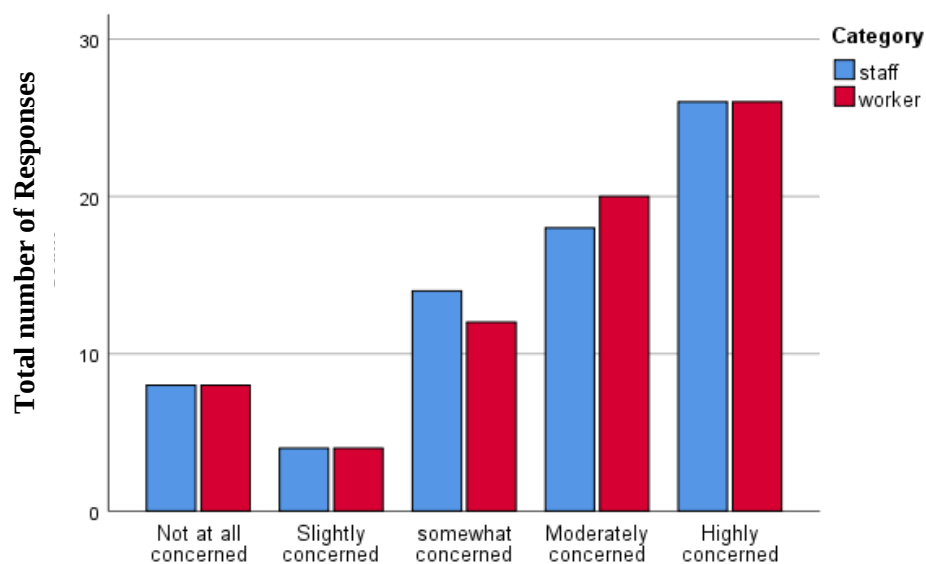


Figure 4.22: Consideration of Performance for calling back to work

When selecting staff and workers for calling to report back to work immediately after the COVID-19 pandemic, the performance was highly considered in both workers and staff categories in order to maintain the quality and efficiency of the work.

Health Condition

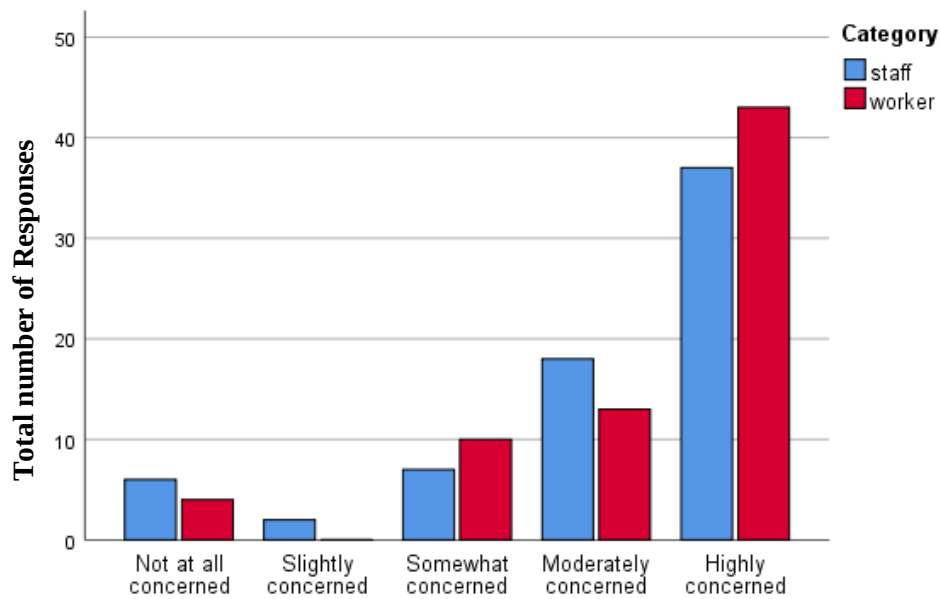


Figure 4.23: Consideration of Health Condition for calling back to work

When selecting staff and workers for calling to report back to work immediately after COVID-19 pandemic, the health condition was highly considered for both workers and staff in order to keep a higher health and fitness level of workforce during work.

Age Level

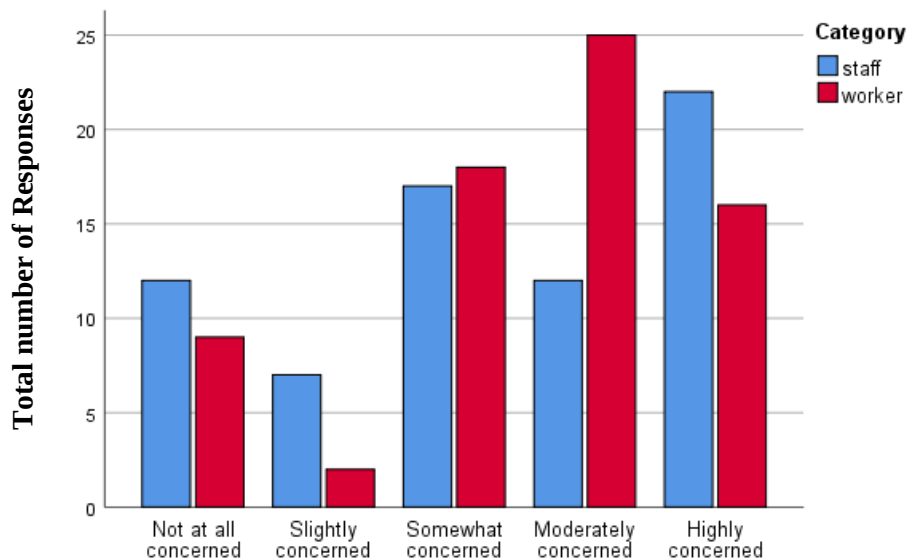


Figure 4.24: Consideration of Age level for calling back to work

When selecting staff and workers for calling to report back to work immediately after the COVID-19 pandemic, their age level was moderately or highly considered most of the time for both workers and staff categories.

Experience

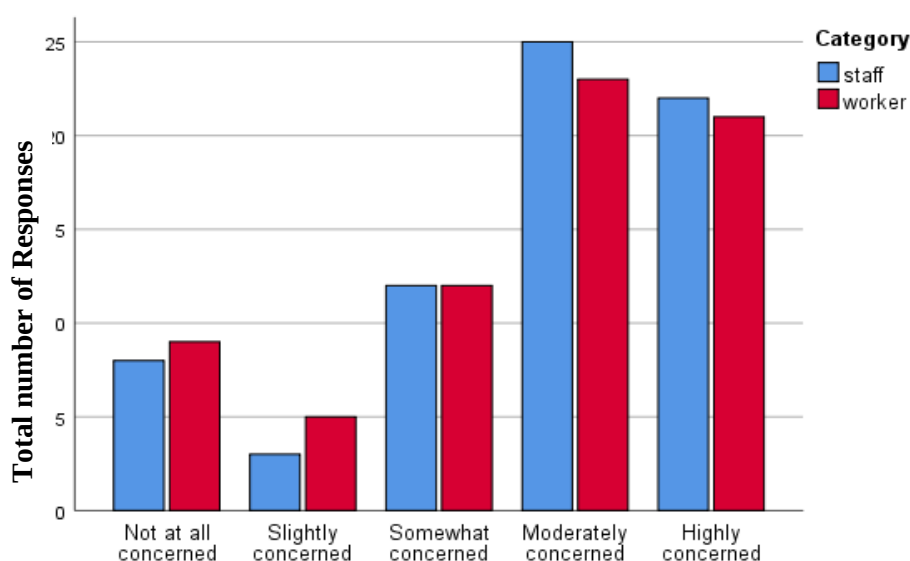


Figure 4.25: Consideration of Experience for calling back to work

When selecting staff and workers for calling to report back to work immediately after the COVID-19 pandemic, their working experience was moderately or highly considered most of the time for both workers and staff categories.

Nationality

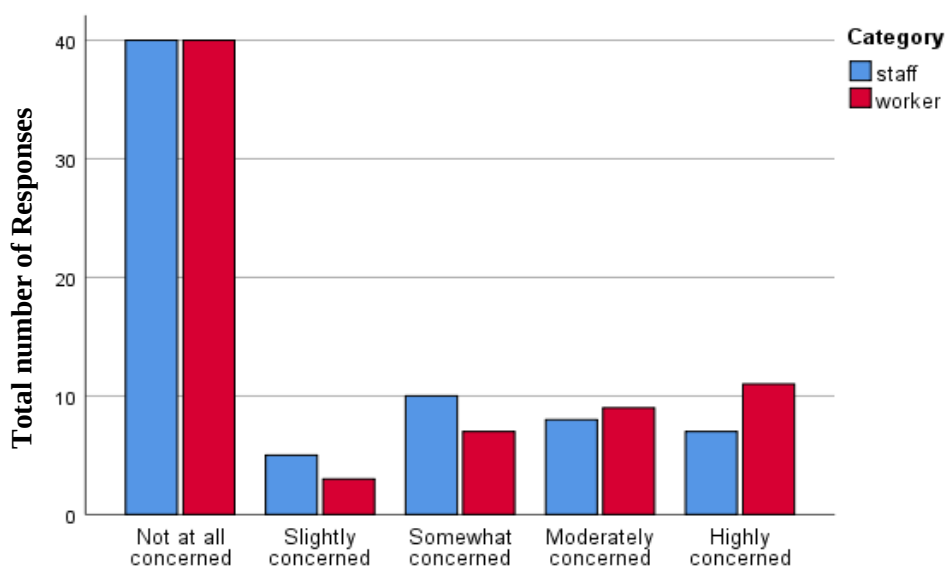


Figure 4.26 : Consideration of Nationality for calling back to work

When selecting staff and workers for calling to report back to work immediately after COVID-19 pandemic, nationality was not considered most of the time for both workers and staff.

Distance from home

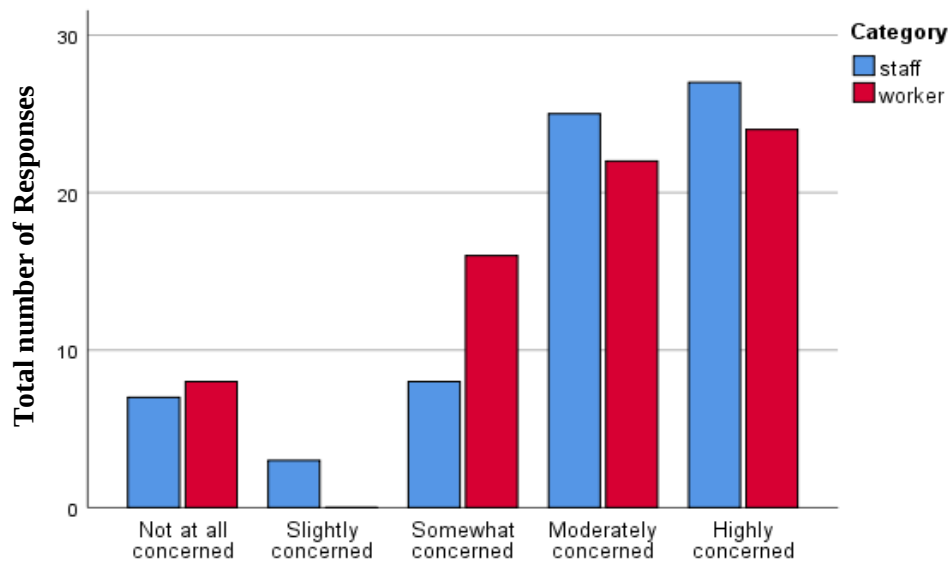


Figure 4.27 : Consideration of 'Distance from home' for calling back to work

When selecting staff and workers for calling to report back to work immediately after COVID-19 pandemic, the distance from home was considered moderately or highly most of the time for both workers and staff categories as employees are exposed to the outside society and under risk while traveling during this COVID-19 pandemic situation.

4.2.2.8 Future Construction methods and strategies

Construction methods and strategies related to workforce management could be changed in construction sites under the impact of the pandemic. In order to identify and compare the concern on construction methods and strategies after the COVID-19 pandemic and before the COVID-19 pandemic, the paired sample T-test was used since responses were recorded on an ordinal scale. Null and alternative hypotheses could be stated as follows.

$$H_0: \mu_{before} \geq \mu_{after}$$

$$H_1: \mu_{before} < \mu_{after}$$

If the one tailed significance value (p-value) is less than 0.05, H_0 is rejected at 5% level of significance.

The following table shows the output of the paired sample T-test for each construction method and strategies category.

Table 4.2: Changes of Construction method and strategies with Covid-19 Pandemic

Pair	Variables	P-value
1	Outsourcing/Subcontracting - Before COVID-19 Outsourcing/Subcontracting - After COVID-19	0.300
2	Using more Precast Elements in Construction - Before COVID-19 Using more Precast Elements in Construction - After COVID-19	0.000
3	Using System formworks for Construction - Before COVID-19 Using System formworks for Construction - After COVID-19	0.000
4	Increasing Efficiency and productivity of workers - Before COVID-19 Increasing Efficiency and productivity of workers - After COVID-19	0.000
5	Restructuring Workforce Management - Before COVID-19 Restructuring Workforce Management - After COVID-19	0.000
6	Training workers regularly - Before COVID-19 Training workers regularly - After COVID-19	0.000
7	Introducing Shift work arrangement - Before COVID-19 Introducing Shift work arrangement - After COVID-19	0.000
8	Introducing less labor-intensive construction methods - Before COVID-19 Introducing less labor-intensive construction methods - After COVID-19	0.000

As per the above results of the paired sample T-test, except for the first pair, all other mean differences of pairs are statistically significant since the one tailed p-values are less than 0.05. Therefore, null hypothesis is rejected for the other 7 pairs. Hence, the conclusions can be drawn under 5% of significance level.

According to the results of the paired sample T-test, consideration of outsourcing /subcontracting of the labour force after COVID-19 has become higher compared to pre COVID-19. The difference in rates of consideration between other methods and strategies before and after COVID-19 are negligible. More consideration of outsourcing/subcontracting of the labour force can be judged as a positive trend in workforce management since laborers are closely supervised and well-coordinated when they are subcontracted, thus reducing the non-productive time.

Table 4.3: Conclusion of results of the paired sample T-test

No	Activity	Consideration after the COVID-19 pandemic
1	outsourcing/Subcontracting of works	Lower
2	Using more Precast Elements in Construction	higher
3	Using System formworks for Construction	higher
4	Increasing Efficiency and productivity of workers	higher
5	Restructuring Workforce Management	higher
6	Training workers regularly	higher
7	Introducing Shift work arrangement	higher
8	Introducing less labor-intensive construction methods	higher

4.2.2.9 Challenges faced regarding workers' management.

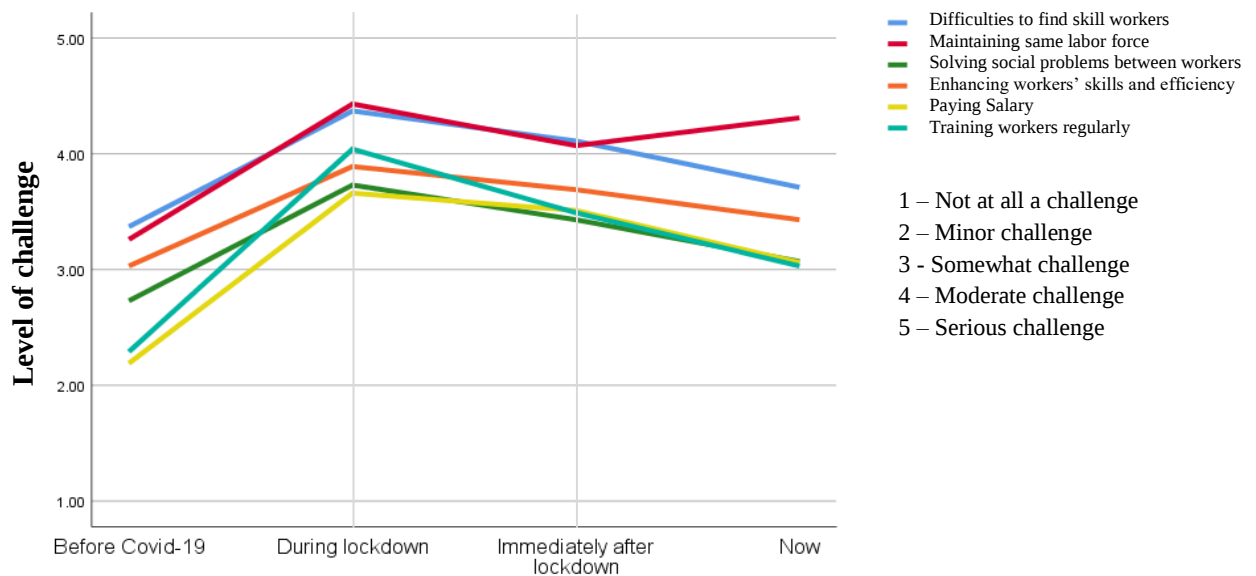


Figure 4.28: Variation of Challenges faced regarding workers' management

As per the Figure 4.28, levels of challenges related to workforce management have been increased during the lockdown period and started to decrease gradually after the lockdown

except for maintaining the same workforce size. The level of challenge for maintaining the same workforce size has decreased immediately after the lockdown but now it has become a major concern according to the obtained results.

4.2.3 Health and Safety

The COVID-19 pandemic situation has highly affected the health and safety strategies in the construction industry. In construction sites, Safety and Medical officers shall be suitably appointed to strictly monitor the workers whether they follow the safety and health instructions accordingly. Furthermore, the responsibilities of safety and medical officers have been changed with the COVID-19 pandemic situation.

4.2.3.1 Consideration of workers/staff about their health and safety

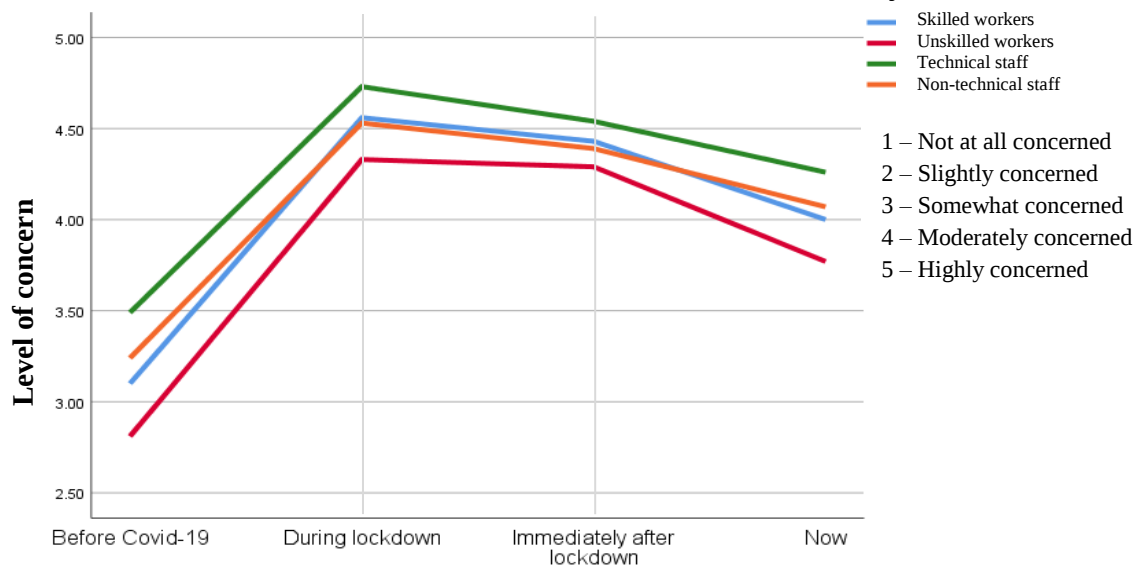


Figure 4.29: Consideration of workers and staff about their health and safety

Figure 4.29 indicates that all workforce categories have considered about their health and safety in a similar way regardless of their professional level. The consideration about the health and safety has been significantly increased during the lockdown period since almost all the people were afraid of novel COVID-19 pandemic. However, with time passing, again workers and staff have considered less about their health and safety.

4.2.3.2 Safety and medical officers in construction sites

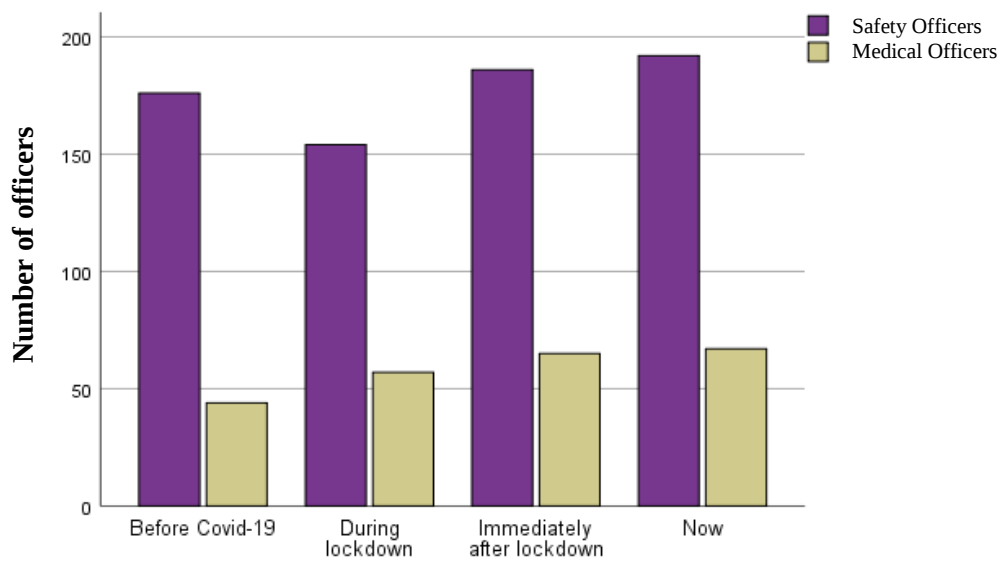


Figure 4.30: Number of Safety and medical officers in construction sites

It is difficult to identify considerable change of the number of medical officers and safety officers in construction sites with respect to the COVID-19 pandemic according to the Figure 4.30. However, there is a clear difference between the number of safety officers and medical officers since construction sites are always keen on “Safety First” and management is highly concerned on safety matters.

Key roles and responsibilities of safety officers

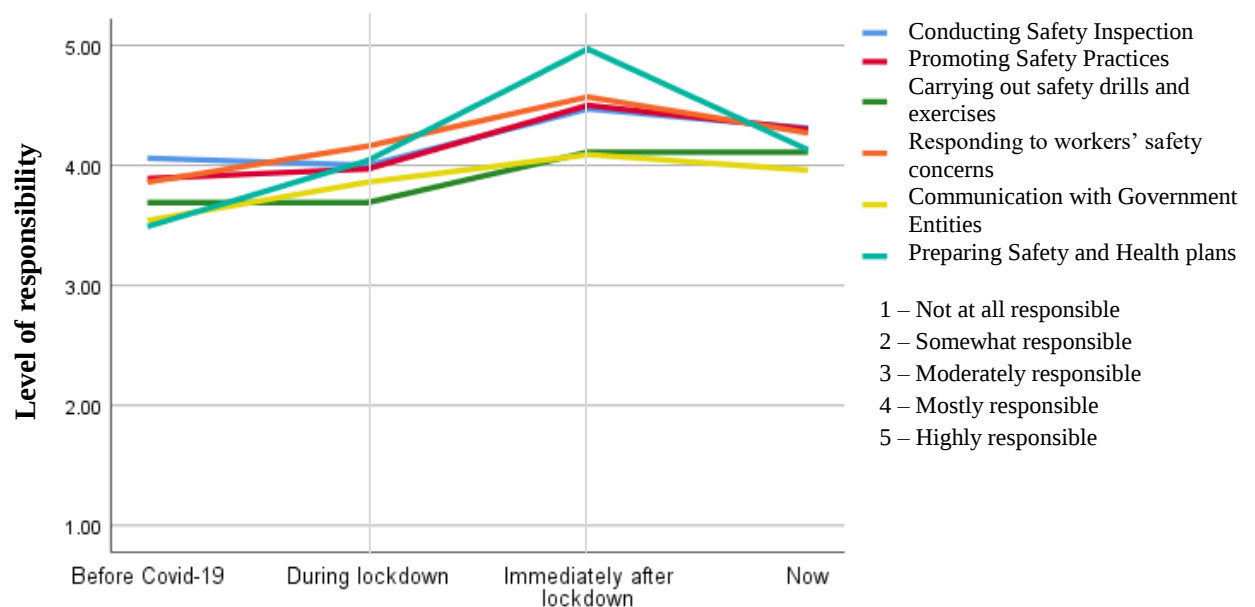


Figure 4.31: Key roles and responsibilities of safety officers

According to above Figure 4.31, it is revealed that the level of responsibility of safety officers about the safety matters at sites have considerably increased during and immediately after the lockdown since construction sites were supposed to practice health and safety regulations issued by health authorities. The practice of such guidelines was strictly monitored and evaluated by relevant authorities as well.

4.2.3.3 Wearing Personal Protective Equipment (PPE) at site

Illustrating the use of PPE at construction sites, Figure 4.32 shows the fluctuation of the usage of PPE by workers at construction sites. It is evident that except for face masks, usage of other PPE items worn by laborers has varied similarly throughout the four (4) time periods considered. However, face masks are worn often than other items during the lockdown period.

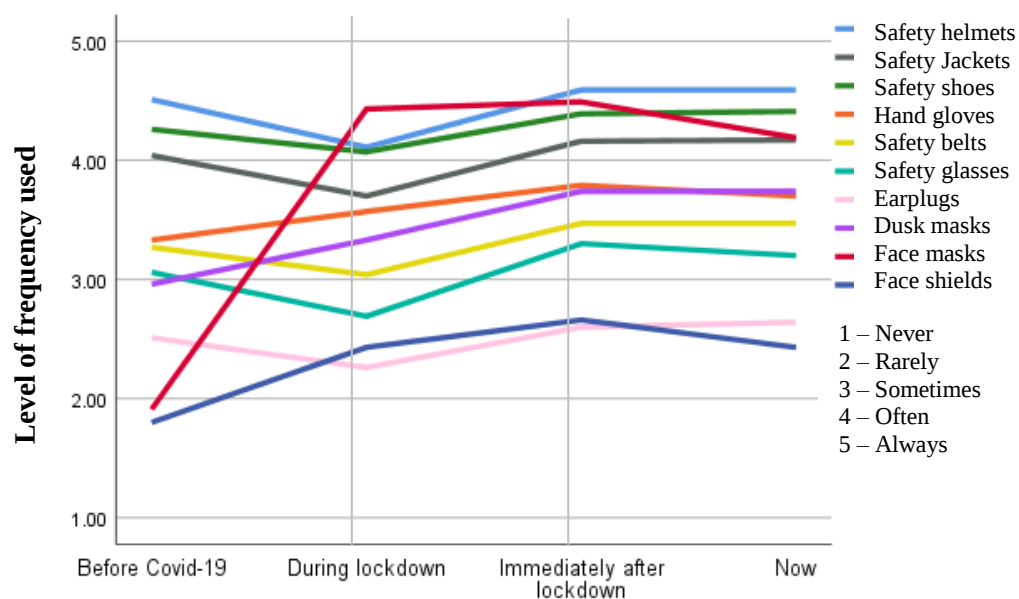


Figure 4.32: Wearing PPE at site

Table 4.4 shows that the correlation between General PPE (Safety helmets, safety jackets, safety shoes, safety belts, safety glasses, earplugs, dusk masks) and PPE used for protecting from COVID-19 (Hand gloves, Face masks, Face shields) throughout the four time periods. It could be concluded that during the lockdown period, the correlation between General PPE and COVID-19 PPE is insignificant. It implies that General PPE and COVID-19 PPE worn by workers in the site during the lockdown has no linear relationship.

Table 4.4: Correlation between General PPE and PPE used to protect from COVID-19

Time period	Pearson Correlation	Significance
Before COVID-19	0.540	Significant
During Lockdown	0.401	Insignificant
Immediately after Lockdown	0.525	Significant
Now	0.456	Significant

4.2.3.4 Medical facilities Provided at sites

In addition to the use of PPE, the study has focused on examining the frequency of providing medical facilities at sites under the impacts of COVID-19. The results highlighted that providing medical facilities such as medical personnel, medical check-ups, first aid supplies, medical rooms, and emergency services have increased after imposing lockdown measures.

According to the Figure 4.33, almost all the considered factors under medical facilities at the site behaved in a similar manner throughout all the periods. The frequency of providing facilities during the lockdown period was increased.

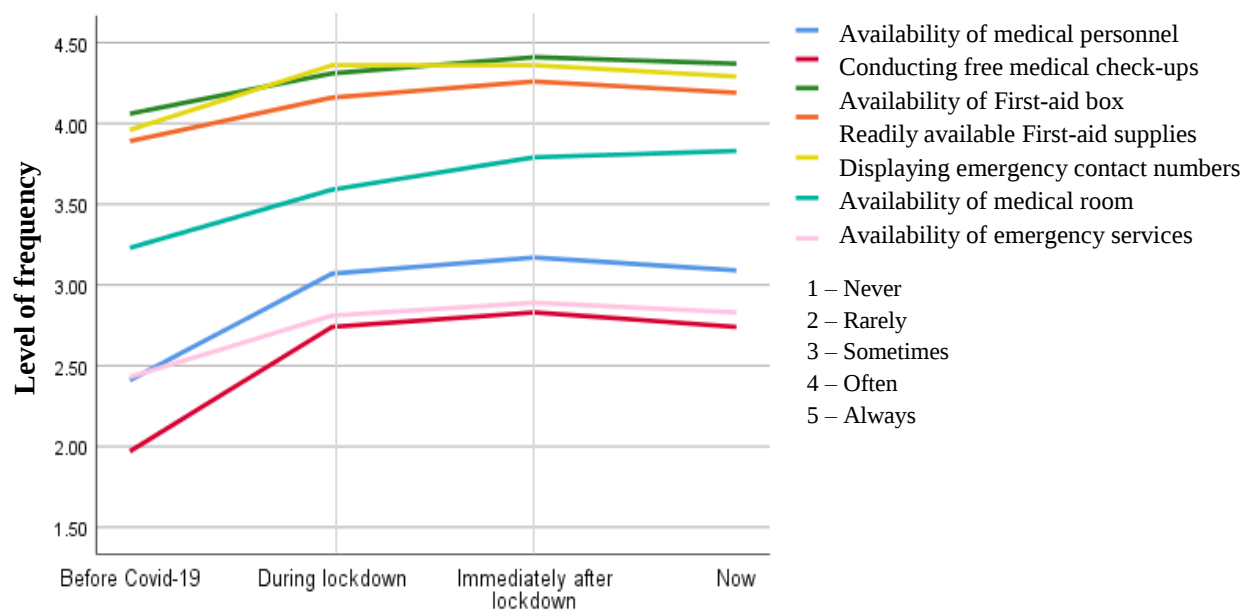


Figure 4.33: Variation of Medical facilities Provided at sites

4.2.3.5 Sanitary practices of workers at sites and dormitories

The level of consideration on health and safety control measures and sanitary practices at sites has significantly increased with the impacts of COVID-19. Figure 4.34 shows that almost all the factors considered under sanitary practices of workers at sites and dormitories behave in a similar way throughout all the time periods. The consideration level of all sanitary practices during the lockdown period was considerably increased. Currently, it is being maintained in the sites and dormitories even though there is a slight drop when compared to the lockdown period. However, it is better to highly consider sanitary practices always to avoid any kind of diseases as construction sites have a higher chance to spread diseases.

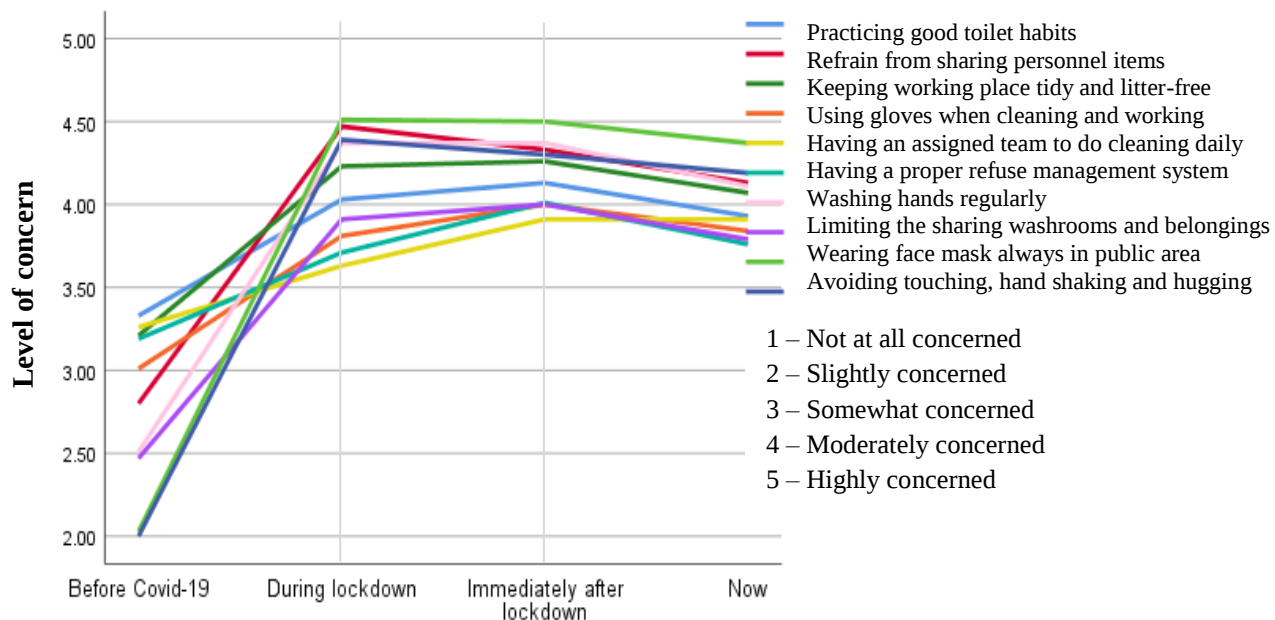


Figure 4.34: Variation of Sanitary practices of workers at sites and dormitories

4.2.3.6 Safety and Health Control measures to avoid COVID-19

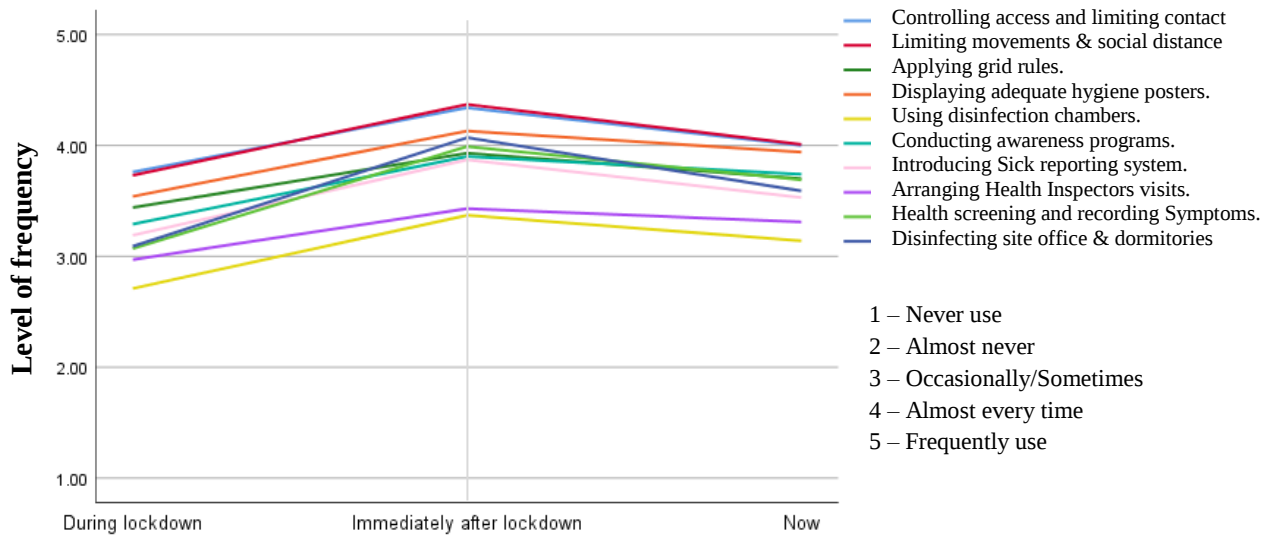


Figure 4.35: Variation of Safety and Health Control measures at sites and dormitories

According to the Figure 4.35, almost all safety and health control measures that have been considered to avoid spreading of COVID-19 at sites and dormitories behave in a similar way starting from lockdown period to now. Introducing all control measures was initiated during the lockdown period. The frequency of implementing above control measures have been extremely increased immediately after the lockdown period.

4.2.3.7 Health and Safety Procedures had to be followed when back to work

For Workers

Table 4.5: Health and Safety Procedures workers had to follow when report back to work

Procedure	Response		
	No (%)	Uncertain (%)	Yes (%)
Health screening and Temperature monitoring	7.1	0.0	92.9
Compulsory Isolation	35.7	11.4	52.9
First PCR	52.1	11.4	31.5
Second PCR	61.4	5.7	32.9
Avoiding contacting after self-quarantine	50.0	20.0	30.0
Applying entry and exit restriction	2.9	10.	87.1

Table 4.5 illustrates that more than 90% respondents have accepted that health screening and temperature monitoring were being followed when workers reporting back to work

immediately after COVID-19. Furthermore, more than 87% of the total respondents have reported that the entry and exit restrictions have been applied when workers are reporting back to work.

For Staff

Table 4.6: Health and Safety Procedures staff had to follow when report back to work

Procedure	Response		
	No (%)	Uncertain (%)	Yes (%)
Health screening and Temperature monitoring	2.9	1.4	95.7
Restrict public transport	17.1	21.4	61.5
Work from home concept	24.3	7.1	68.6
Online Communication	12.9	21.4	65.7
Limiting working days	22.9	15.7	61.4
Shift work	31.4	18.6	50.0

According to the Table 4.6, more than or equal 50% of respondents have stated that the staff had to follow the above mentioned procedures when reporting back to work.

4.2.3.8 Challenges faced regarding health and safety at sites

Figure 4.36 shows that almost all the challenges have been increased during the lockdown period. However, with time, all these challenges have reduced due to surviving the pandemic.

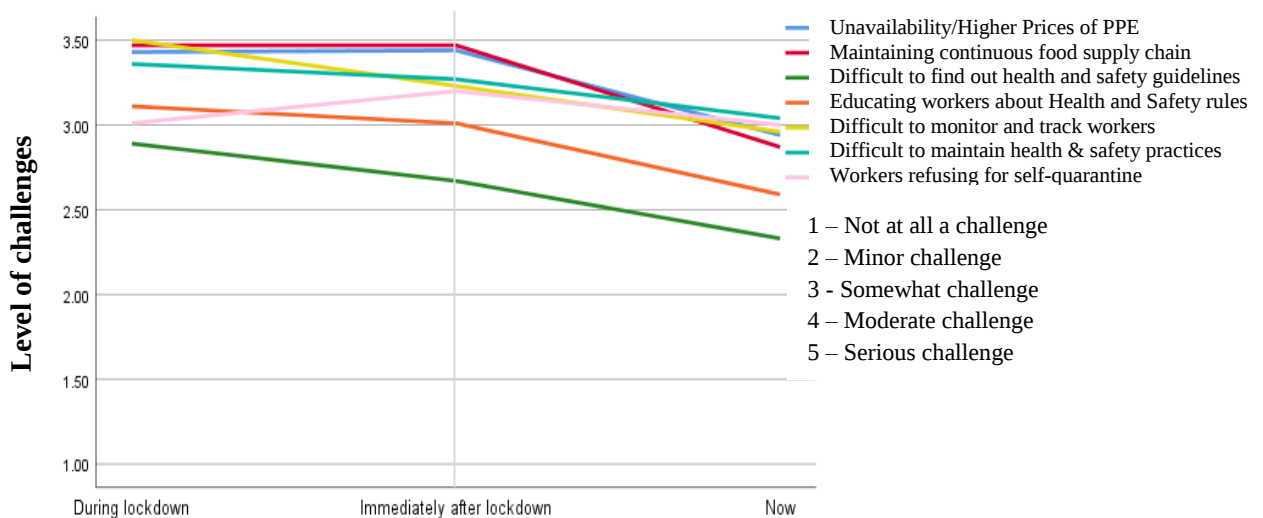


Figure 4.36: Variation of Challenges faced regarding health and safety at sites

4.2.4 Welfare Facilities

The impact of the dengue pandemic on providing labour accommodations and its conditions, sanitary facilities, transport facilities, and supplying meals were evaluated under welfare facilities. In Construction industry, these facilities improve the morale of the personnel to work.

4.2.4.1 Providing Accommodation for Workers

Figure 4.37 clearly depicts that more workers have accommodation inside the site before COVID-19 pandemic compared to the other time phases. There was a significant drop of the number of workers accommodated inside the site during the lockdown. However, it has gradually increased immediately after the lockdown.

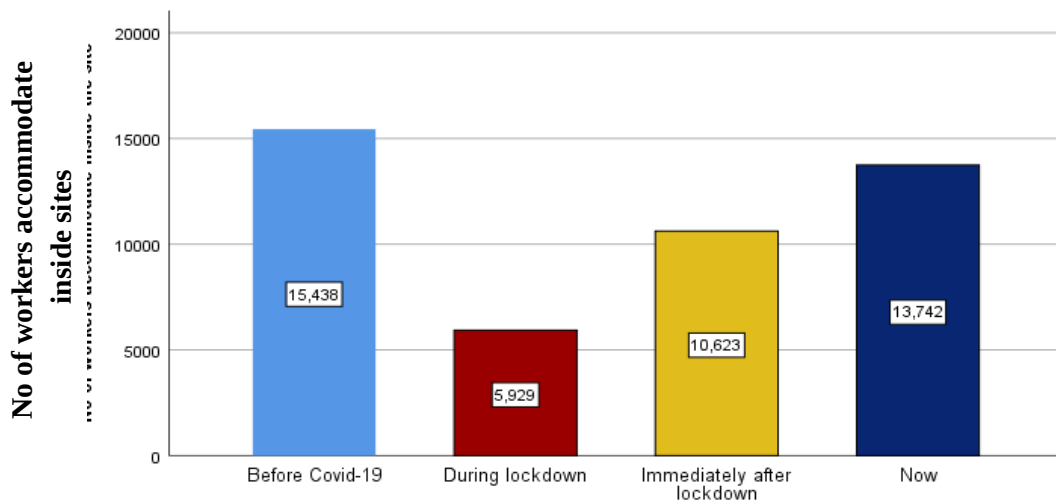


Figure 4.37: Providing Accommodation facility inside the site

The bar chart shown in Figure 4.38 clearly illustrates that more workers have been accommodated outside the site before the COVID-19 pandemic. There was a significant drop in the number of workers accommodated outside the site during the lockdown behaving similarly to the graph on inside accommodation. However, it has gradually increased immediately after the lockdown. Furthermore, the number of workers accommodated inside site remained higher than outside.

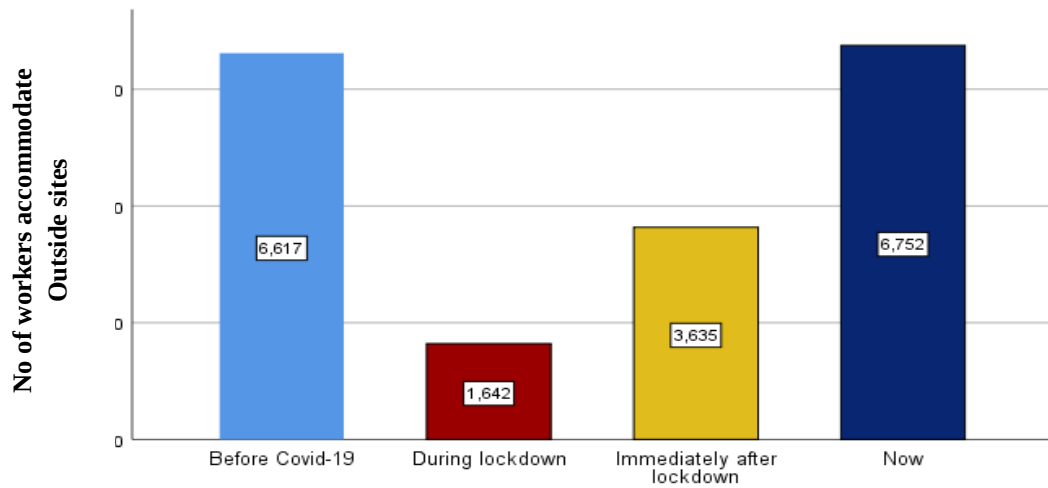


Figure 4.38: Providing Accommodation facility Outside the site

This Figure 4.39 reflects that the number of workers accommodated in dormitories that are not owned by construction companies has increased during the lockdown period and started to decline gradually immediately after. But findings have highlighted that a considerably high number of laborers have stayed in those accommodations without returning.

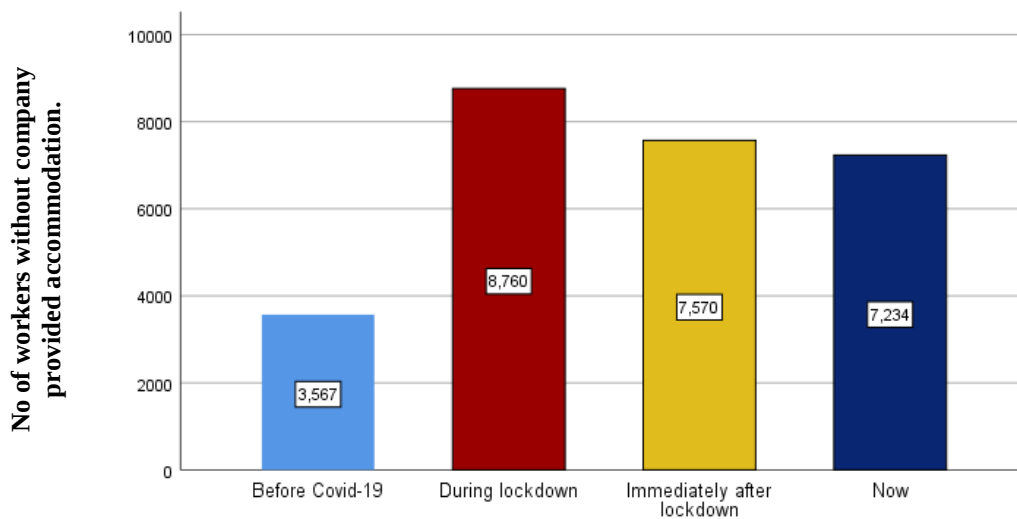


Figure 4.39: Workforce without company provided Accommodation facility

4.2.4.2 Facilities Provided for Workers

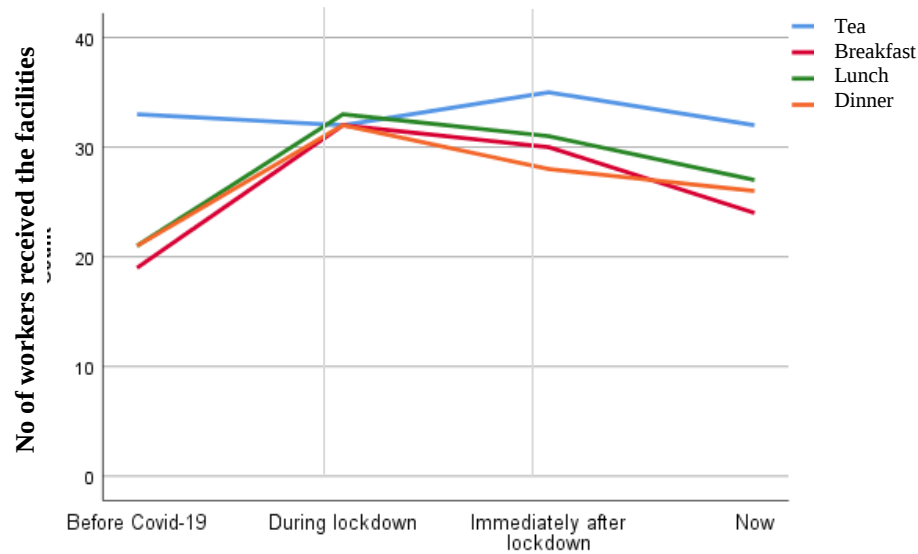


Figure 4.40: Facilities Provided for workers in dormitories located inside the Sites

As per the Figure 4.40, the total number of respondents who stated that they were provided tea is highest in all periods. Number of respondents who stated that they were provided other facilities (Breakfast, Lunch & Dinner) increased during the lockdown period since they had to stay in their dormitories fulltime and there was no way to buy meals from outside.

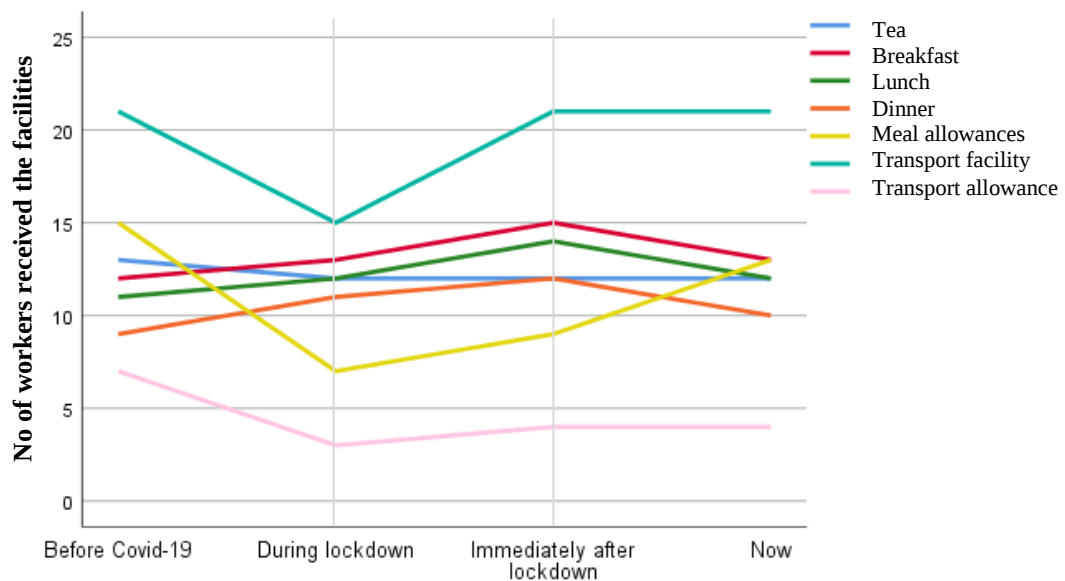


Figure 4.41: Facilities Provided for workers in dormitories located outside the Sites

Figure 4.41 shows that the number of respondents who stated that workers were provided with meal allowance, transport facility and transport allowance have been reduced during the lockdown period. However, number of respondents who stated that workers received meals were increased during the lockdown period since they had to stay in their dormitories throughout the lockdown period.

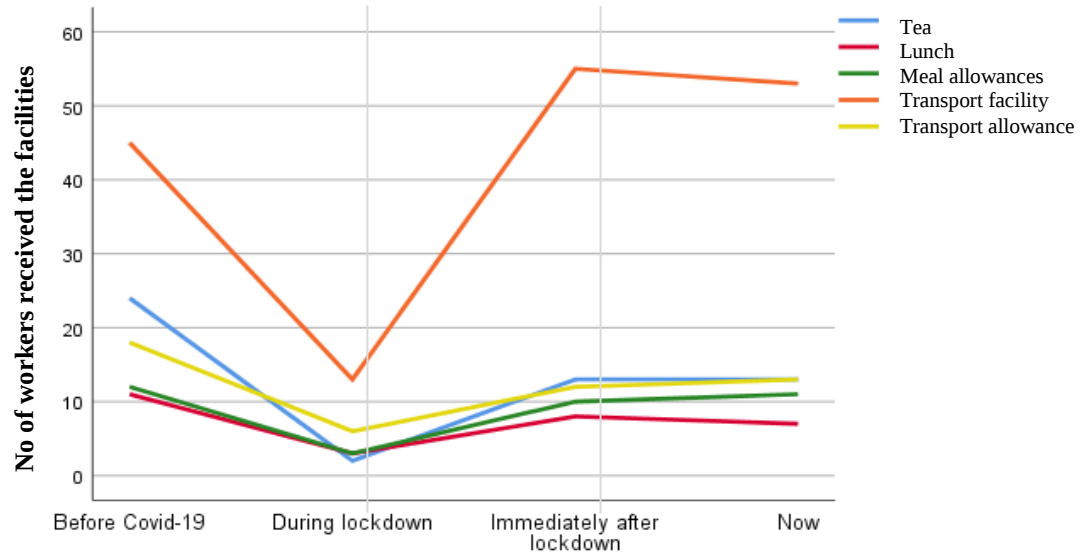


Figure 4.42: Facilities provided who do not have dormitories

Figure 4.42 indicated that the number of respondents who do not have dormitory facility stated that workers received tea were higher than other facilities during all periods. All the facilities for workers who did not have dormitory facility were reduced during the lockdown period. After the lockdown period, again all the facilities have been increasing.

4.2.4.3 Physical Conditions of a Dormitory room

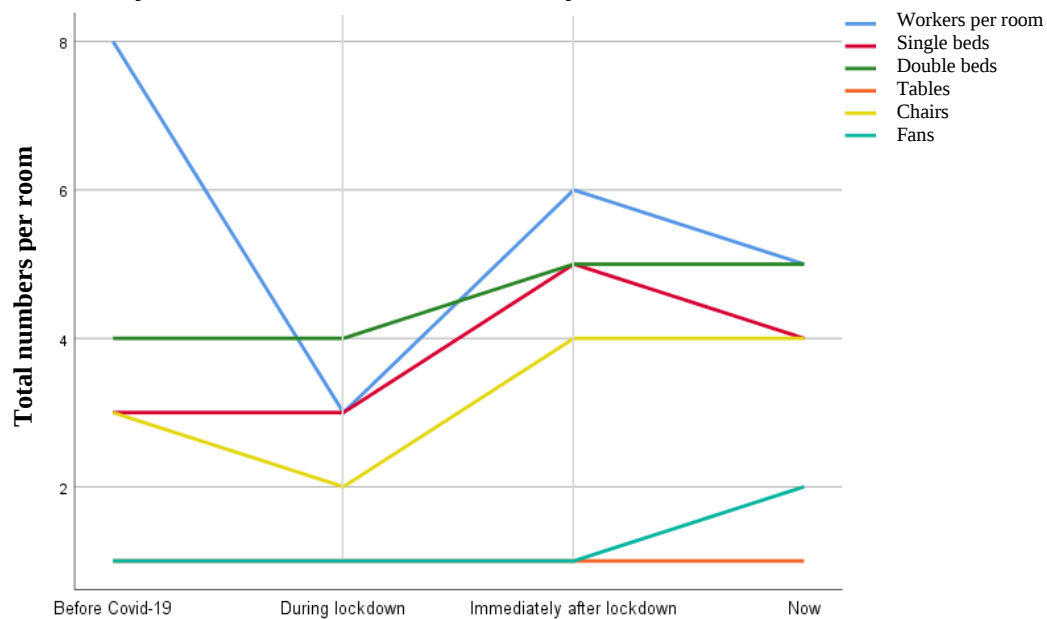
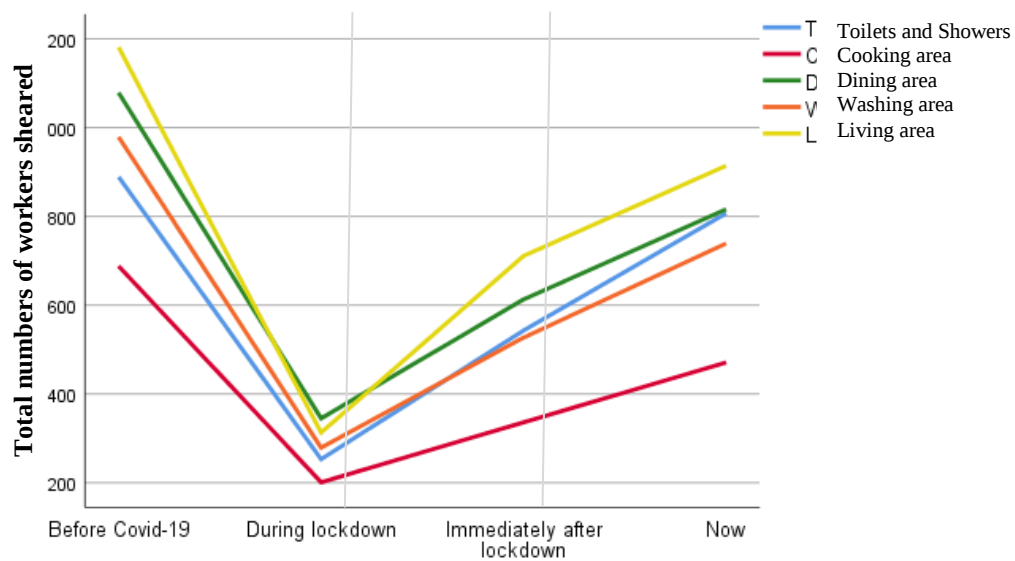


Figure 4.43: Physical facilities Provided for workers in dormitories

According to the Figure 4.43, the number of workers allocated per room were reduced drastically during the lockdown since people had to maintain social distance and most of the workers went back to their permanent residences. Other facilities increased immediately after the lockdown in order to maintain social distance and concerning health and safety. However, other facilities were constant throughout the time period considered.

4.2.4.4 Sharing common facilities between workers at dormitories



4.44: Sharing common facilities between workers at dormitories

Figure

The way of sharing the common facilities by the workers at dormitories shows in Figure 4.44 and it behaves in a similar manner throughout the considered time periods. Sharing common facilities have been drastically reduced during the lockdown period to limit the contact and maintain social distance between workers. However, it has again started to increase moderately with the time.

4.2.4.5 Challenges faced when providing welfare facilities

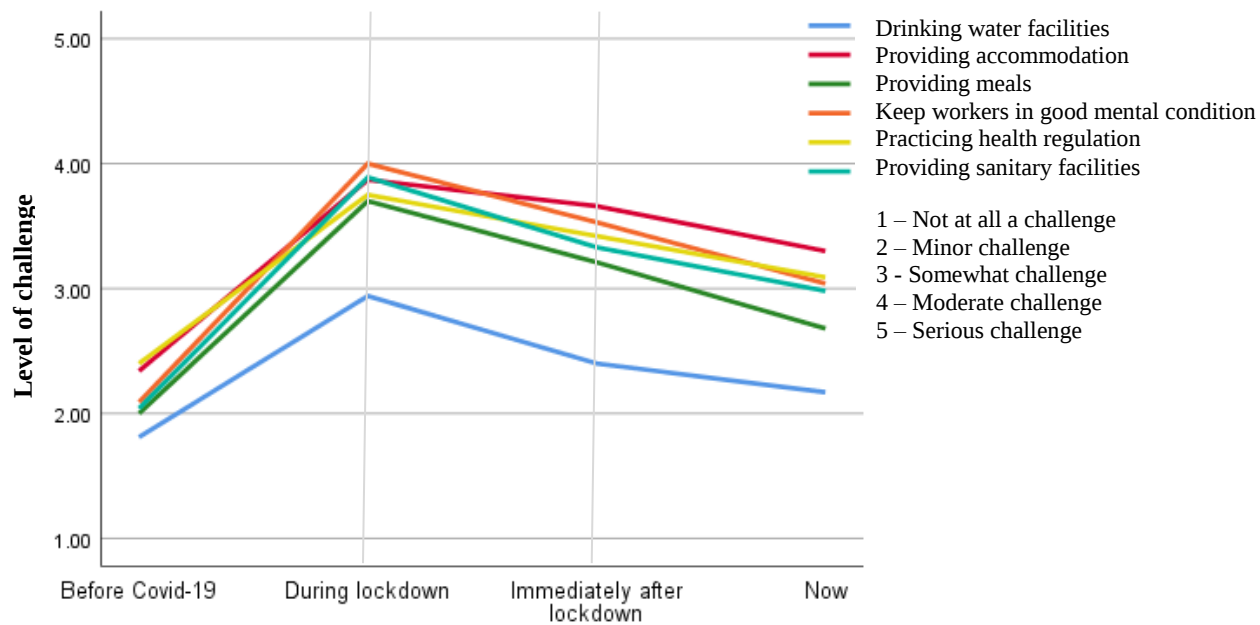


Figure 4.45: Sharing common facilities at dormitories

According to the Figure 4.45, all the challenges faced when providing welfare facilities for workers were increased during the lockdown period and level of the challenges were gradually decreasing after the lockdown period.

4.2.5 Emergency and Disasters

4.2.5.1 Dengue Outbreak

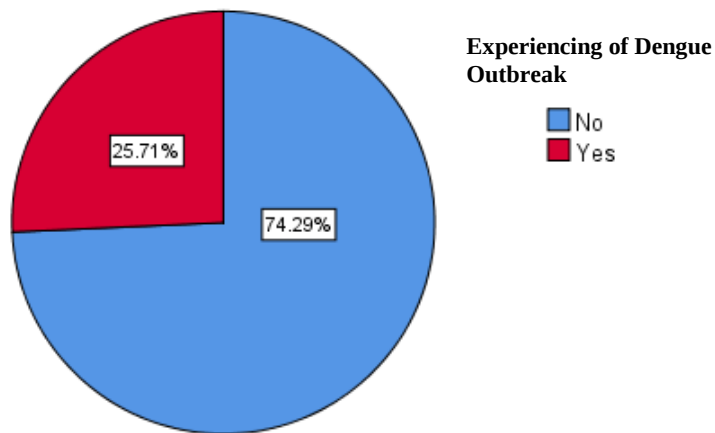


Figure 4.46: Percentage of Dengue Outbreak experienced at construction sites

Figure 4.46 highlights that the level of experience on past dengue outbreaks of laborers is considerably low. Only 25.71% of respondents have experienced any dengue outbreak in their sites during their working period.

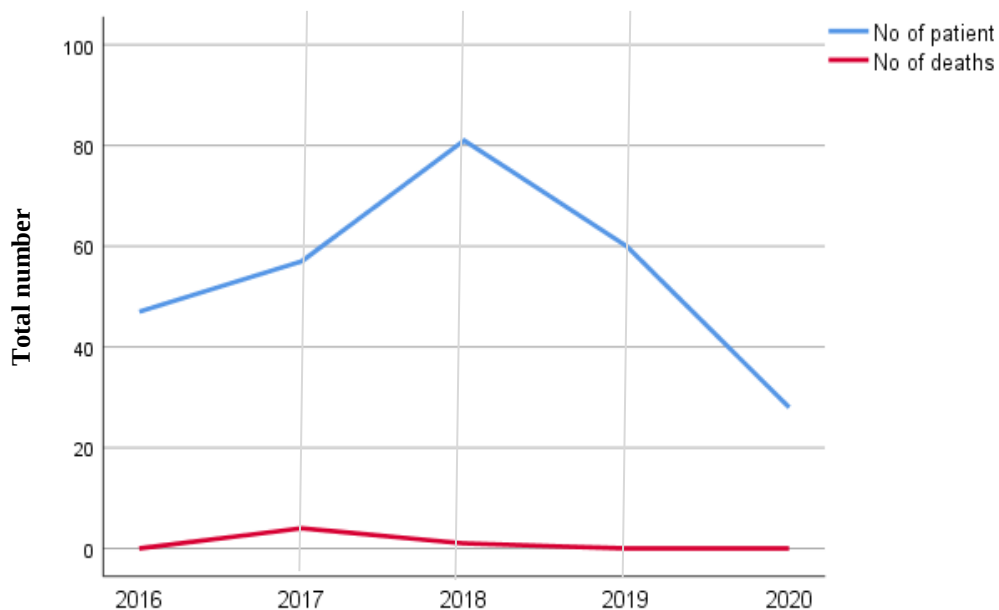


Figure 4.47: Report of Dengue patients and deaths at construction sites

As per the Figure 4.47, there was a peak of the number of dengue patients in construction sites in 2018. However, number of deaths occurred were fortunately very low when compared to the total cases in each year.

4.2.5.2 COVID-19 Outbreak

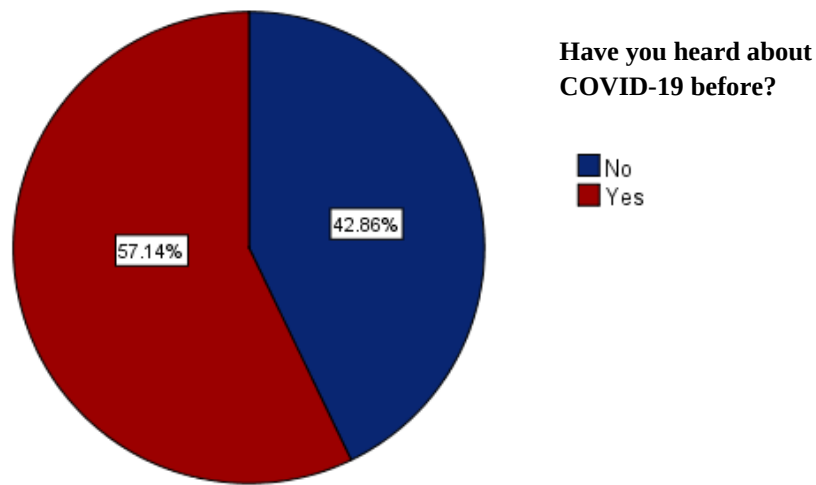


Figure 4.48: Responses about hearing COVID-19 before

According to the findings of the questionnaire survey as shown in the Figure 4.48, 42.86% of respondents have stated that they were not aware of the impacts of the COVID-19 pandemic adequately. Respondents who have heard about the COVID-19 outbreak adequately (52.14% of total respondents) have mostly used TV/Radio news and social media to get information about the pandemic. It can be considered as a good trend since construction professionals are moving towards technological platforms in order to receive information related to emergencies. This trend has negative impacts as well since false information can be shared through technological platforms such as social media especially in health-related emergencies.

Table 4.7: Media of how people heard about COVID-19

Source	No (%)	Yes (%)
TV/Radio News	47.1	52.9
Newspapers	71.4	28.6
Social Media	57.1	42.9
Internet	60.0	40.0
Friends/Society	81.4	18.6
Other	94.3	5.7

As per the Figure 4.49, before the COVID-19 pandemic starts in Sri Lanka, 78.57% of respondents have not expected this kind of a pandemic in the country. Therefore, the preparedness for disruptions to the industry by a pandemic should be at a considerably low level although necessary actions have been initiated to address issues arising due to epidemics such as dengue.

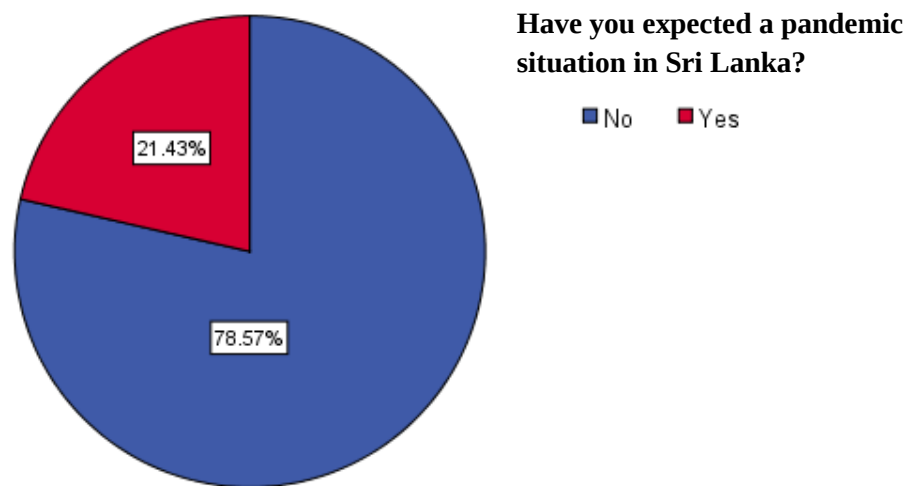


Figure 4.49: Expectation of a pandemic situation in Sri Lanka

4.2.5.4 Preparation for Emergency situations, disasters, and pandemics

A paired sample T-test was used in order to identify the impact of lessons learned from the COVID-19 pandemic on preparation for emergency situations, disasters and pandemics. This means the rate of concern on disaster preparedness before and after the pandemic were compared using the paired sample T-test. Null and alternative hypotheses could be stated as follows.

$$H_0: \mu_{before} \geq \mu_{after}$$

$$H_1: \mu_{before} < \mu_{after}$$

If the one tailed significance value (P-value) is less than 0.05, H_0 is rejected at 5% level of significance. Following Table 4.8 shows the output of paired sample T-test for each preparation methods.

Table 4.8: Output of paired sample T-test for each preparation methods for emergency

Pair	Variables	P-value
1	Availability of Emergency action plan - before COVID-19 Availability of Emergency action plan - after COVID-19	0.000
2	Enhancing workers' awareness about emergency - before COVID-19 Enhancing workers' awareness about emergency - after COVID-19	0.000
3	Allocating key personnel for emergency control - before COVID-19 Allocating key personnel for emergency control - after COVID-19	0.000
4	Establishing Emergency escape routes - before COVID-19 Establishing Emergency escape routes- after COVID-19	0.000
5	Availability of Siren for emergency - before COVID-19 Availability of Siren for emergency - after COVID-19	0.000
6	Availability of Fire protection and firefighting facilities-before COVID-19 Availability of Fire protection and firefighting facilities - after COVID-19	0.000
7	Availability of Emergency rescue equipment - before COVID-19 Availability of Emergency rescue equipment - after COVID-19	0.000
8	Preparing Risk assessments and safe work procedures -before COVID-19 Preparing Risk assessments and safe work procedures -after COVID-19	0.000
9	Displaying emergency contact numbers - before COVID-19 Displaying emergency contact numbers - after COVID-19	0.000
10	Conducting safety drills regularly - before COVID-19 Conducting safety drills regularly - after COVID-19	0.000

All pairs have a significant difference in mean values of concentration rates of preparation methods. This implies that the concern on preparation for emergency situations, disasters and pandemics after the COVID-19 pandemic is higher than before COVID-19 pandemic.

4.2.5.5 Usage of Covid-19 Guidelines and References

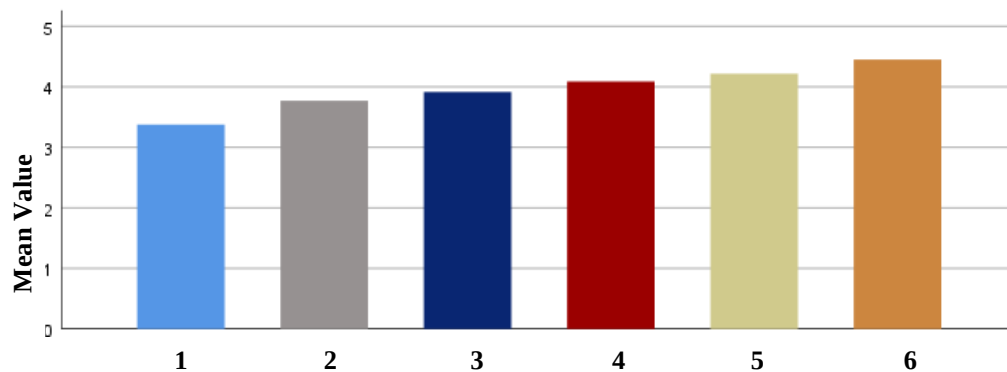


Figure 4.50: Usage of COVID-19 Guidelines and References

1. "Situation Reports" - *Epidemiology Unit of Ministry of Health & Indigenous Medical Services*
2. "Advice for high-risk country returnees" - *Epidemiology Unit of Ministry of Health & Indigenous Medical Services*
3. "Public Advised Form" - *Epidemiology Unit of Ministry of Health & Indigenous Medical Services*
4. "Novel Corona virus (COVID-19) advice for the public" – *World Health Organization*
5. "Operational guidelines on preparedness and response for Covid-19 outbreak for work settings" - *Ministry of health and indigenous medical services*
6. "Guidance for workplace preparedness for COVID-19" - *Epidemiology Unit Ministry of Health & Indigenous Medical Services*

The bar chart shown in the Figure 4.50 indicates that the respondents have followed all the guidelines and references most of the time to get information about COVID-19 pandemic at construction sites.

4.3 Summary

The COVID-19 pandemic has a drastic impact on Sri Lanka's construction industry that has resulted in slowing down the economy. It is a well-known fact that Sri Lanka's construction industry is considered as the backbone of the country's economy. Mainly, the construction industry was affected due to the island wide lockdown (52 days) imposed by GOSL that restricted all the movement. Most of the construction companies have been reducing their workforce including staff and workers. Furthermore, the new safety guidelines, health practices and emergency regulations relevant to COVID-19 have restricted the construction industry to operate as usual. The declining usual conditions of the construction industry resulted in challenging conditions for employees and project managers to operate the construction activities. Therefore, COVID-19 has changed the construction methods, safety and healthcare practices of the construction industry in Sri Lanka controlling the opportunities and facing new challenges.

CHAPTER FIVE

5.0. DISCUSSION

5.1 Introduction

Under the previous chapter, the findings of the study were analyzed and discussed. This chapter will mostly discuss the outcome of the previous chapter. Furthermore, this chapter intends to summarize and conclude the study while explaining limitations of the research study.

5.2 Summary of the Study

The construction industry provides a significant contribution to the economy of Sri Lanka. The Construction industry cannot be transferred to an online or remote mode and is identified as the most vulnerable and adversely affected sector by the COVID-19 pandemic. To overcome negative outcomes occurred, even though it cannot be prevented completely, it is essential to take action to prevent the spreading of COVID-19 in construction sites and workers dormitories. Therefore, it is important to identify and comprehensively analyze the effects of COVID-19 pandemic on the construction industry of Sri Lanka. The main aim of this research is to identify and analyze the effects of COVID-19 for Construction industry of Sri Lanka in different ways such as workforce management, safety and healthcare strategies, welfare facilities and planning for emergency situations by achieving a set of objectives. The first objective of this study was to identify and analyze the workforce management processes and strategies and the second objective was to identify and analyze the welfare facilities provided by the construction sites. The next objective was to identify and analyze the welfare facilities provided by the construction sites. Then the final objective was to identify and analyze the preparation of construction sites for emergency, disasters and pandemic situations.

5.3 Summary of the Findings

As stated above, the aim of the research was achieved by accomplishing the objectives. The summarized findings under each of the above research objectives have been described here.

Objective One - Analyzing the workforce management processes and strategies.

This objective was achieved by analyzing the effect of COVID-19 pandemic for the management of workers and staff in the construction projects. It was identified that the total workforce and the standard working hours at sites have been drastically reduced during the lockdown period due to COVID-19. Due to the reduction of the workforce at sites, a significant number of employees have been terminated unexpectedly. It has highly affected the work progress of construction sites. When selecting workers to terminate their jobs and calling back to work, the management has highly considered the workers' age, performance, and health condition while considered less about basic salary and nationality of workers. During the lock-down period, to reduce the overall expenses of sites, it has been identified that the salary of workforce and overtime payments have been reduced. In addition to that, it was discovered that construction sites are planning to change the construction methods in the future in order to reduce the dependency on manpower. Furthermore, the level of challenges faced by the project management team have been increased during the lock down period.

Objective Two - Investigating the health & safety practices and strategies.

This objective was also achieved through analyzing the collected data. Accordingly, it was identified that the consideration of workers and staff health and safety has been increased regardless of their professional levels during the lock-down period. All responsibilities of safety officers regarding safety matters in construction sites have been significantly increased immediately after the lockdown when compared to other time periods. It clearly demonstrated that except face masks, other PPE items worn by workers are in a similar manner throughout the four time periods considered. Medical facilities at the sites have been provided in a similar manner throughout all the periods. Frequency of providing all facilities during the lockdown period was increased. All the sanitary practices of workers at sites and dormitories behaved in a similar pattern throughout the all-time periods. The consideration level of all sanitary practices and safety and health control measures during the lockdown period was considerably increased. However, it is

recommended to maintain a higher concern on sanitary practices always to avoid any kind of diseases in construction sites and dormitories. Furthermore, it was identified that more than 90% respondents have accepted that health screening and temperature monitoring were being followed when workers reporting back to work immediately after COVID-19. The challenges related to health and safety have been considerably increased during the lockdown period.

Objective Three - Evaluating the welfare facilities that the construction sites provide.

After analyzing the collected data, the third objective was also accomplished. It was identified that more workers have accommodated in dormitories (inside and outside the sites) before COVID-19 pandemic. However, there was a significant drop in the number of workers accommodated in dormitories during the lockdown period while number of workers who did not have accommodation facility increased. Furthermore, it was revealed that other facilities (Breakfast, Lunch & Dinner) were increased for workers during the lockdown period since they had to stay in their dormitories fulltime and there was no way to buy meals from outside. Number of workers per room were reduced drastically during the lockdown since people had to maintain social distance and most of the workers went back to their permanent residences. The way of sharing the common facilities by the workers at dormitories behaved in a similar manner throughout the considered time periods while sharing common facilities have been drastically reduced during the lockdown period to limit the contacts and maintain the social distance between workers. Furthermore, all the challenges faced when providing welfare facilities at construction sites were increased during the lockdown period and the level of challenges were gradually started decreasing after the lockdown period.

Objective Four - Examining the preparation of construction sites for emergency, disasters and pandemic situations

Through the study, the preparation of construction sites for emergency and disasters was analyzed as the fourth objective. It was identified that most of the workers, 74.29% of total respondents have not experienced any dengue outbreak at their construction sites. Furthermore, 57.14% of total respondents have heard about COVID-19 and most of the respondents have heard through TV/Radio news and social media. However, most of the respondents (78.57%) have not expected to experience this kind of pandemic in Sri Lanka.

The study further implies that the concern for preparation for emergency situations, disasters and pandemics after the COVID-19 pandemic has been significantly increased compared to the COVID-19 pandemic situation before. Furthermore, it was identified that the construction sites have followed all the guidelines and references most of the time to face COVID-19 pandemic at construction sites.

CHAPTER SIX

6.0. CONCLUSION AND RECOMMENDATIONS

This research has investigated and analyzed the consequences of COVID-19 pandemic in the construction industry including both private and public sectors. The lockdown of construction projects for 52 days (from 20th of March 2020 to 11th of May 2020) had a high impact on the construction industry of Sri Lanka which was recognized statistically. It was identified that the impact was in different directions such as job losses, time overrun, cost overrun, and financial influence. In addition to that, it was identified that the impact of COVID-19 is significant to the stakeholders and the workforces in the construction industry regardless of the type of construction or type of the company. The project managers have worked hard to mitigate the impact of COVID-19 by reducing the workforce on-site and promoting off-site work to avoid and slow down the spread of the pandemic situation. This kind of unforeseen impacts are unquestionably troubling the flow of the project's progress. With the COVID-19 pandemic situation, the construction projects in Sri Lanka have faced many challenges related to workforce management, health and safety, welfare facilities and preparation for emergencies. The findings of this research are important to the top management in the construction industry to realize the impact of the unexpected and uncontrolled pandemic situation. Furthermore, the outcome will assist to enhance the accuracy of management decisions and strategies related to dealing with any pandemic situation in the future.

According to the overall findings, it could be concluded that the pandemic has rendered severe disruptions and challenges to the industry. Especially, proper workforce management and maintaining health and safety can be identified as major challenges. The challenges with workforce management can be mainly addressed by selecting and employing the optimum crew composition with maximum productivity. Workers who are not returning to sites on time have become another issue regarding workforce management. Recruiting more local laborers who are closer to sites can be recommended as a solution for this issue. In addition to that, in selecting optimum crew composition, the following factors can be considered, health; age; experience; performance. Furthermore, there is a trend towards subcontracting and outsourcing laborers currently. This strategy promotes the close supervision of laborers, thus reduces the average non-productive time.

During the pandemic, the concern on health and safety matters has been considerably increased due to the uncertainty of getting infected with the virus. Not following health and safety standards and low level of PPE usage were identified as severe problems even before the pandemic. However, with the impact of COVID-19, strict health guidelines have been developed to curtail the transmission of the virus at sites and the responsibilities of safety and medical officers increased considerably. Furthermore, a poor level of disease surveillance activities among laborers was highlighted as a severe threat. This issue could be addressed by developing SOPs for disease surveillance and allocating more financial resources. Furthermore, changing the attitudes of laborers through health and safety sessions, safety drills, and awareness programmes is essential to address several issues related to health and safety at sites.

Poor welfare facilities such as crowded accommodations, absence of clean water, crowded dining areas, etc. heighten the potency of spreading communicable diseases among laborers rapidly. Therefore, the administration of construction companies should take necessary actions such as reducing the number of workers per room, establishing more accommodations outside the site, providing meals and transportation, and increasing sanitary facilities in labour accommodations to stop construction sites from being a red spot during an outbreak. Furthermore, emergency preparedness in construction sites can be enhanced through proper emergency plans, emergency drills, and awareness campaigns.

This research can be further extended to incorporate sustainable construction practices for the recovery of the construction industry beyond the COVID-19 pandemic. Apart from those, mechanisms to combine disaster resilience strategies during the construction phase should be explored.

This global pandemic situation has stressed the limitations of managing construction sites. In this context, COVID 19 has increased the necessity for Project Managers to plan construction sites more out of the box such as management processes, health and safety strategies and construction methods to face future virus attacks and pandemic situations. However, construction industry in the post-pandemic period will face several challenges that require a good understanding of the behavior of COVID 19 and its direct and indirect effects on construction processes.

The conclusions of the research studied under four main categories could be summarized as follows with recommendations.

Table 6.1: Summary of main challenges faced and recommendation.

Category	Challenges	Recommendation
1) Workforce management	Workers not returning to work on time	- Recruit more local workers for the construction sector - Consider the distance from home to site when recruiting.
	Maintaining size of the optimum crew size at construction sites	Find optimum crew composition for activities
	Low performance level of the workers	- Improve skill level of workers - Introduce proper coordination system at sites
	More person-to-person contacts at sites	- Introduce proper coordination system - Improve planning of construction activities
	Lack of close supervision	Sub-contracting and outsourcing
2) Health and Safety strategies	Not following health and safety standards adequately	- Introduce strict rules and guidelines - Increase duties and responsibilities of Safety Officers - Changing attitudes of workers towards health and safety practices
	Low level of PPE usage	- Introduce strict rules and guidelines and close monitoring - Increase duties and responsibilities of Safety Officers - Changing attitudes of workers towards health and safety practices
	Contamination of Virus at the workplace	- Use of more face masks, dust masks and gloves - Apply entry and exit restrictions - Improve personnel hygiene

	• Poor sanitary facilities at sites	• Increase number of washrooms • Provide drinking water and washing facilities
	• Low level of disease surveillance procedures among workers	• Develop SOPs for disease surveillance • Enhance the cleanliness of sites
	• Poor health conditions at sites	• Provide more medical facilities • Recruit more medical officers
3) Providing Welfare facilities	• Crowded accommodation	• Reduce number of workers per room • Providing accommodation outside the site
	• Lack of sanitary facilities at accommodation	• Provide more beds, fans, chairs, etc. • Increase number of washrooms • Continuous supply of clean water
	• Providing transport facilities for workers	• Provide comfortable transport facilities by the company • Provide transport allowances
	• Providing meals	• Establish canteen facilities and resting areas • Provide meal allowance • Provide cooked food
4) Preparing Construction Sites for Emergencies and Disasters	• Poor Risk Assessments	• Preparing and updating risk assessments continually
	• Lack of facilities for emergencies	• Proper maintenance of equipment • Continuous training of officers • Increase number of equipment required for emergencies
	• Lack of Emergency Plans	• Develop emergency plans with emergency routes
	• Low level of preparedness	• Conduct emergency drills • Develop and disseminate SOPs to be followed in a Disaster
	• Lack of awareness	• Develop and disseminate SOPs to be followed in a Disaster • Conduct awareness and training program

There is no end to the COVID 19 pandemic in the near future and, the future of the construction industry remains uncertain. However, the experience of the pandemic has assisted us in predicting what the post-pandemic construction industry might look like.

Based on the research findings, the following recommendations can be made, in order to improve the management processes and strategies in the construction industry in Sri Lanka to successfully face any emergency pandemic situation in the future.

1. Based on the present situations and emergency measures in construction sites, it is required to review and update existing management strategies and planning theories relevant to emergencies at construction sites.
2. It is recommended to build a sustainable environment and strengthen the health and safety measures in construction sites for not only to prevent any pandemic situations but also as a recovery approach that could be implemented in the post-pandemic period.
3. Based on the lessons learnt in the construction industry from this COVID-19 pandemic crisis, this study identifies the importance of implementing antivirus construction environment in Sri Lanka's construction industry that might further aid to stop the virus spreading or mitigate its impacts.
4. It is recommended to find out what preventive measures are most appropriate to keep the pandemic situations controlled in construction sites and dormitories, while causing minimum disruption to the construction industry. In addition to that, it is important to establish successful partial lockdown strategies by considering the transmission of the pandemic disease when construction activities are permitted.
5. The professional bodies and the other relevant organizations related to the construction industry in Sri Lanka should take much more steps to enhance and uplift the knowledge of health and safety measures related to pandemics in the construction industry.

Recommendation given for Other Industries

The COVID-19 pandemic has shocked industries around the world and will likely have a growing and potentially long-lasting impact on the world economy. The pandemic has created a devastating effect on worldwide economies and manufacturing industries. Due to this pandemic situation, supply chain disruptions occurred in the manufacturing sector, which has created a butterfly effect on various other sectors. Therefore, many industries have proposed different strategies and plan to face and overcome the pandemic situation.

Working remotely has dramatically increased the digitization of many essential services. These services have been applied to many industries and the services are able to be delivered remotely online from anywhere in the world. For the retail and consumer industry, retailers are encouraged to go online since lockdowns and social distancing measures affect retailers with physical stores more than online retailers. In addition to that, adopting new digital experiences for consumers by using 'personal contactless' delivery of goods is highly recommended. In addition to that, it is suggested to provide specific guidance for health and safety in retail stores easing regulations on essential retail activities. For the tourism industry, it has been suggested to lift travel restrictions and apply new health protocols for safe travel and help to diversify their markets. Furthermore, improving the tourists' confidence to travel following the COVID-19 health and safety measures is highly recommended. To achieve this requirement, it is advised to prepare a comprehensive tourism recovery plan to rebuild the tourism industry. When it comes to the apparel and textile industry, it is recommended to maintain the manufacturing plants with health and safety protocols and plan longer strategies to deal with social distancing mainly in factories and other locations. Furthermore, it is suggested to encourage middle-management people to keep a close watch on workers' activities and increase the frequency of COVID-19 update meetings. Implementing the remote working facility and introducing the virtual sampling process are also advised to apply to the apparel and textile industry. For the Banking and Finance Sector, it is suggested to conduct a comprehensive review of customers, assess the level of vulnerability of each category to the impact of the outbreak, and develop a scenario-based risk mitigation strategy. Furthermore, Banks must adapt their operating models to drive efficiency during pandemic situations encouraging customers to shift to digital services, from account opening to mortgage applications. Providing guidance for health and safety in banks and financial institutions is also highly recommended.

BIBLIOGRAPHY

- (2020). Retrieved from <http://www.epid.gov.lk>:
http://www.epid.gov.lk/web/index.php?option=com_content&view=article&id=225&Itemid=
- Ahmadian Fard Fini, A. a. (2018). Dynamic programming approach toward optimization of workforce planning decisions. *Journal of Construction Engineering and Management*, 144.
- Al Amri, T., & Marey, M. (2020). Impact of Covid-19 on Oman's Construction Industry. *Technium Social Sciences Journal*, 661-670.
- Araya, F. (2020). Modeling the spread of COVID-19 on construction workers: An agent-based approach. *Safety science*, 133, 105022.
- Ayittey, F. K., Ayittey, M. K., Chiwero, N. B., Kamasah, J. S., & Dzuovor, C. (2020). Economic impacts of Wuhan 2019-nCoV on China and the world. *Journal of Medical Virology*, 473-475.
- Chaudhry, C. M. (1991). *Research Methodology*. Rajasthan: RBSA Publishers.
- COVID-19 epidemic in Sri Lanka: A mathematical and computational modelling approach to control. (n.d.).
- Criterion for Registration, Grading and Monitoring of Main Construction Contractors*. (2017). Colombo: Construction Industry Development Authority (C.I.D.A.).
- Drosten, C., Gnther, S., Preiser, W., Van Der Werf, S., Brodt, H.-R., Becker, S., . . . Fouchier, R. A. (2003). Identification of a novel coronavirus in patients with severe acute respiratory syndrome. *New England journal of medicine*.
- Erandi, H., Mahasinghe, A. C., Perera, S., & Jayasinghe, S. (2020). Effectiveness of the strategies implemented in Sri Lanka for controlling the COVID-19 outbreak. *medRxiv*.
- Fellows, R., & Liu, A. (2003). *Research methods for construction*. Blackwell Publishing .
- Fernandes, N. (2020). *Economic effects of coronavirus outbreak (COVID-19) on the world economy*.
- Gamil, Y., & Alhagar, A. (2020). The Impact of Pandemic Crisis on the Survival of Construction Industry: A Case of COVID-19. *Mediterranean Journal of Social Sciences*, 122-122.
- Gopalakrishnan, G., & Brindha, G. (2017). A study on employee welfare in construction industry. *Technology*, 07-12.
- Harari, Y. N. (2020). The world after coronavirus. *Financial Time*.

- (2020). *Health and Immunity Enhancement Guidelines for Covid-19 and Dengue*. Colombo: Construction Industry Development Authority.
- Health and Safety Guidelines for Sri Lankan Construction Sites to be adopted during COVID-19 outbreak*. (2020). Colombo: Construction Industry Development Authority.
- Helm, D. (2020). The environmental impacts of the coronavirus. *Environmental and Resource Economics*, 21-38.
- Hui, D. S. (2020). The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health—The latest 2019 novel coronavirus outbreak in Wuhan, China. *International Journal of Infectious Diseases*, 264--266.
- Ivanov, D. (2020). Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review*, 136.
- Kothari, C. R. (2008). *Research methodology: Methods and techniques*. New Age International.
- Kraemer, K., & Pinsonneault, A. (1993). Survey research methodology in management information systems: an assessment. *Journal of Management Information Systems - Special section: Strategic and competitive information systems*, 75-105.
- Li, Q. a., Leung, K. S., Lau, E. H., & Wong, J. Y. (2020). Early transmission dynamics in Wuhan, China, of novel coronavirus--infected pneumonia. *New England journal of medicine*.
- Mahasinghe, A. C., Erandi, H., & Perera, S. (2020). An optimal lockdown relaxation strategy for minimizing the economic effects of covid-19 outbreak in Sri Lanka. *medRxiv*.
- McEntire, D. A. (2015). *Disaster response and recovery: strategies and tactics for resilience*. John Wiley & Sons.
- Meade, R. R. (2020). CDJ Editorial—What is this Covid-19 crisis?
- Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., . . . Agha, R. (2020). The socio-economic implications of the coronavirus and COVID-19 pandemic: a review. *International journal of surgery*.
- Punch, K. F. (2005). *Introduction to Social Research: Quantitative and Qualitative Approaches*. London: Sage Publications Ltd.

- Queiros, A., Faria, D., & Almeida, F. (2017). Strengths and Limitatipns of Qualitative and Quantitative Research Methods. *European Journal of Education Studies*, 369-387.
- Raja Prasad, S., & Prasad Rao, Y. (2012). Optimization of Emergency Management System in a Construction Organization in India. *International journal of research in industrial engineering*, 26-38.
- Roshana, M., Kaldeen, M., & Banu, A. R. (2020). Impact of Covid-19 outbreak on Sri Lanka Economy. *Journal of Critical Reviews*, 7, 2124-2133.
- Roshana, M., Kaldeen, M., & Banu, A. R. (2020). IMPACT OF COVID-19 OUTBREAK ON SRI LANKAN ECONOMY. *Journal of Critical Reviews*, 2124-2133.
- Said, H., Kandil, A., & Cai, H. (2012). Agent-based simulation of labour emergency evacuation in high-rise building construction sites. In *Construction Research Congress 2012: Construction Challenges in a Flat World* (pp. 1104-1113).
- Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students*. Essex: Pearson Education.
- Tan, W. (2002). *Practical research methods*. Jurong: Prentice Hall.
- Tan, W. (2008). *Practical Research Methods*. London: Pearson Education .
- The way forward after COVID-19*. (2020). Colombo: Construction Industry Development Authority.
- Uma Sekaran, U. (2003). *Research Methods for Business A Skill-Building Approach*. New York: John Wiley & Sons.
- Uzun, M., Bilir, S., & Cebi, S. (2018). Hierarchy of Control Measures for Common Construction Activities: A Field Study. In *5th International Project and Construction Management Conference*.
- Velavan, T. P., & Meyer, C. G. (2020). The COVID-19 epidemic. *Tropical medicine and international health*.
- WHO. (2020). Retrieved from world health organization: <https://www.who.int/>
- Wickramaarachchi, T., Perera, S., & Jayasinghe, S. (2020). COVID-19 epidemic in Sri Lanka: A mathematical and computational modelling approach to control. *medRxiv*.
- Yin, R. (2003). *Case StudyResearch: Design and Methods*. California: Sage Publishing.

Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., . . . Huang, C.-L.
(2020). A pneumonia outbreak associated with a new coronavirus of probable bat
origin. *nature*, 270-273.

ANNEXURES

ANNEXURE – 1

WORKFORCE MANAGEMENT, SAFETY, HEALTHCARE AND WELFARE STRATEGIES IN CONSTRUCTION SITES IN THE CONTEXT OF COVID-19 PANDEMIC.

M.Sc. in Construction Project Management

Department of Civil Engineering

University of Moratuwa

Dear Sir/Madam,

I am a Postgraduate student at Department of Civil Engineering, Faculty of Engineering, University of Moratuwa. As a partial fulfillment to the M.Sc. Degree construction schedule, I need to carry out a research project in the study area. The study area details are as follows:

Title:

Workforce Management, Safety, Healthcare and Welfare Strategies in Construction Sites in the Context of COVID-19 Pandemic.

Aim:

This research is aimed to identify the workforce management, safety, healthcare, and welfare strategies used in construction sites in the context of COVID-19 Pandemic and determine the significant strategies, management processes and improvements required for construction sites to be adopted to successfully face any pandemic situations in future.

Objectives:

1. Analyzing the workforce management processes and strategies.
2. Investigating the health & safety practices and strategies.
3. Evaluating the welfare facilities that the construction sites provide
4. Examining the preparation of construction sites for emergency, disasters and pandemic situations.

To achieve these objectives, it is required to conduct a Questionnaire Survey. The questionnaire survey is one of the most widely used data collection techniques within the

survey strategy. In this questionnaire survey, each person (respondent) is asked to respond to the same set of questions, and it provides an efficient way of collecting responses from a large sample prior to quantitative analysis.

A Likert scale is a psychometric scale that has multiple categories from which respondents choose to indicate their opinions, attitudes, or feelings about a particular issue. Likert-scale questionnaires have most frequently been used in investigations of individual difference variables, freely without affecting the mental condition of the respondent. I am pleased to inform you that you have been selected to take part in this survey and kindly request your fullest participation and cooperation. This collected data will be used for academic purpose only.

I assure you that this information will be kept confidential and only the summarized results will be provided in the report and therefore no specific reference will be made to experts who take part of this survey.

Thank you.

Yours Faithfully,

.....

Niroshana U.W.A.N.
M.Sc. Candidate
Department of Civil Engineering
University of Moratuwa
Mobile: 0718932218

Research Supervisor:

Dr. Chandana Siriwardana
Senior Lecturer
Department of Civil Engineering
University of Moratuwa
Mobile: 0777555655

WORKFORCE MANAGEMENT, SAFETY, HEALTHCARE AND WELFARE STRATEGIES IN CONSTRUCTION SITES IN THE CONTEXT OF COVID-19 PANDEMIC.

This questionnaire is a part of the research study, and your participation is completely voluntary. Information in this questionnaire will remain completely confidential and be used solely for the academic purposes. Further, I am not requesting you to provide your name, company name etc, as I want to assure your anonymity. I would really appreciate if you could spend few minutes of your precious time to fill the questionnaire. There are 42 questions in this survey. For the data collection, the following time phases have been considered,

Time Phase considered	Time Duration
Before COVID 19 Pandemic	Before 20.03.2020
During Lock-down period	From 20.03.2020 to 11.05.2020
Immediately after Lock-down period	From 11.05.2020 to 11.08.2020
Now	From 11.08.2020 to 31.11.2020

SECTION A: GENERAL INFORMATION

(A1) What is the **type** of your company?

- Government
- Semi-government
- Private
- Foreign
- Other, please specify

(A2) What is the **role of your company** in the site?

- Client / Employer
- Consultant
- Main Contractor
- Sub-Contractor

- Other

(A3) What is the current **grade** of your company and the type **of construction** involved?

	CS2	CS1	C1	C2	C3	C4	C5	C6	C7	C8	C9	Other
Building Construction												
Highway Construction												
Bridge Construction												
Water Supply and Sewerage												
Irrigation and Drainage Canals												
Dredging and Reclamation												
Storm Water disposal and Land Drainage												
Maritime Construction												

(A4) How many construction **projects** are handled by your company?

Time Period	Number of Projects
Before COVID 19 Pandemic (Before 20.03.2020)	
During Lock-down period (From 20.03.2020 to 11.05.2020)	
Immediately after Lock-down period (From 11.05.2020 to 11.08.2020)	
Now (From 11.08.2020 to date)	

(A5) For how many days, your construction sites were fully **lock-down** due to COVID 19 pandemic?

SECTION B: WORKFORCE MANAGEMENT

(B1) What is the workforce **composition** of your construction site?

Time Period	Local Workers	Foreign Workers	Local Staff	Foreign Staff
Before COVID 19 Pandemic				
During Lock-down period				
Immediately after Lock-down period				
Now				

(B2) What are the **differences** between **local and foreign** workforce?

	Local Workforce					Foreign Workforce				
	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Efficiency										
Confidence										
Attitude										
Reliability										
Productivity										
Communication Skills										
Teamwork										
Leadership										

(B3) What are the **standard working hours** at your site?

Time Period	Starting Time					Finishing Time				
	7.00 AM	7.30 AM	8.00 AM	8.30 AM	9.00 AM	4.00 PM	4.30 PM	5.00 PM	5.30 PM	6.00 PM
Before COVID 19 Pandemic										
During Lock-down period										
Immediately after Lock-down period										
Now										

(B4) How do you allow and limit **overtime** work for **workers** and **staff**?

Time Period	Workers (Hours/Month)					Staff (Hours/Month)				
	No	1-50	51-100	101-150	Unlimited	No	1-50	51-100	101-150	Unlimited
Before COVID 19 Pandemic										
During Lock-down period										
Immediately after Lock-down period										
Now										

(B5) How do you pay **salary** for **workers** and **staff**?

Time Period	Workers (% of salary paying)					Staff (% of salary paying)				
	No Salary	1% - 25%	26% - 50%	51% - 75%	76% - 100%	No Salary	1% - 25%	26% - 50%	51% - 75%	76% - 100%
Before COVID 19 Pandemic										
During Lock-down period										

Immediately after Lock-down period										
Now										

(B6) Have you **reduced workforce** during lock-down period?

Yes	
No	
No Answer	

(B6a) How many **numbers of jobs** have been **reduced** during lock-down period?

	Terminating Employment	Resigning from work	Not reporting to work	Other Reason
Number of Local Workers				
Number of Foreign Workers				
Number of Local Staff				
Number of Foreign Staff				

(B6b) what are the **factors** you have considered when **selecting workers / Staff** to **terminate** their jobs?

	Workers					Staff				
	Not at all concerned	Slightly concerned	Somewhat concerned	Moderately concerned	Highly concerned	Not at all concerned	Slightly concerned	Somewhat concerned	Moderately concerned	Highly concerned
Basic Salary										
Performance										
Health Condition										
Age										
Experience										
Nationality										
Distance from home										
Basic Salary										

(B6c) What has happened to the **reduced foreign workforce** after leaving the company?

Reason	Number of workers
Went back to mother country	
Stayed in Quarantine Centers	
Stayed temporary in dormitories	
Joined with other companies	
Others	

(B7) what are the **factors** you have considered when **selecting workers/staff** calling for **back to work** immediately after lock-down period?

	Workers					Staff				
	Not at all concerned	Slightly concerned	Somewhat concerned	Moderately concerned	Highly concerned	Not at all concerned	Slightly concerned	Somewhat concerned	Moderately concerned	Highly concerned
Basic Salary										
Performance										
Health Condition										
Age										
Experience										
Nationality										
Distance from home										

(B8) Are you planning to change **workforce composition** in the future?

Worker Nationality	Increase	Same	Decrease
Local work force			
Foreign work force			

(B9) What kind of **construction methods** and **strategies** are used by your company?

	Before COVID 19 Pandemic					Before COVID 19 Pandemic				
	Not at all concerned	Slightly Concerned	Somewhat Concerned	Moderately Concerned	Highly Concerned	Not at all concerned	Slightly Concerned	Somewhat Concerned	Moderately Concerned	Highly Concerned
Outsourcing / Subcontracting works										
Using more precast elements in construction										
Using system formwork for construction										
Increasing efficiency and productivity of workers										
Restructuring workforce management										
Training workers regularly										
Introducing shiftwork arrangement										
Introducing less labor-intensive construction methods										

(B10) What kind of **challenges** do you face with respect to workers' management?

1 – Not at all a challenge, 2 – Minor challenge, 3 - Somewhat challenge,
4 – Moderate challenge, 5 – Serious challenge

	Before COVID 19 Pandemic	During lock- down period	Immediately after lockdown period	Now
Difficulties to find out new skilled workers				
Maintaining same labor force for a long period				
Solving social problems/conflicts in between workers				
Enhancing workers' skills and efficiency				
Paying Salary for workers				
Training workers regularly				

SECTION C: HEALTH AND SAFETY

(C1) Do you think that workers / staff are concerned about their health and safety?

*1 – Not at all concerned, 2 – Slightly concerned, 3 – Somewhat concerned,
4 – Moderately concerned, 5 – Highly concerned*

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Skilled Workers				
Unskilled Workers				
Technical Staff				
Non-technical Staff				

(C2) How many safety and medical officers are allocated per site?

	Before COVID 19 Pandemic	During lock- down period	Immediately after lockdown period	Now
Number of Safety officers				
Number of Medical officers				

(C3) What are the key roles and responsibilities of Safety Officers at site?

*1 – Not at all responsible, 2 – Somewhat responsible, 3 – Moderately responsible,
4 – Mostly responsible, 5 – Highly responsible*

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Conducting continuous safety inspections at the site				
Promoting safe practices at the site				

Carrying out safety drills and exercises on managing emergency situations				
Responding to workers' safety concerns				
Communicating with government departments with regard to safety concerns				
Preparing emergency, health and safety plans				

(C4) What kind of PPE are worn by workers at site?

1 – Never, 2 – Rarely, 3 – Sometimes, 4 – Often, 5 – Always

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Safety Helmets				
Safety Jackets / high-visibility garments				
Safety Shoes				
Hand Gloves				
Safety Belts				
Safety glasses				
Earplugs				
Dusk Masks				
Surgical Face masks				
Face Shields				

(C5) What are the medical facilities provided at your sites?

1 – Never, 2 – Rarely, 3 – Sometimes, 4 – Often, 5 – Always

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Availability of Medical personnel at the site				
Conducting a free Medical check-up regularly				

Availability of First-Aid Box at the site				
Readily available First-Aid supplies				
Displaying Emergency contact numbers				
Availability of Medical Room at the site				
Availability of Emergency Ambulance service				

(C6) What are the workers' level of concerns about sanitary practices at sites and dormitories?

*1 – Not at all concerned, 2 – Slightly concerned, 3 – Somewhat concerned,
4 – Moderately concerned, 5 – Highly concerned*

	Before COVID 19 Pandemic	During lock- down period	Immediately after lockdown period	Now
Practicing good toilet habits				
Refrain from sharing personnel items and belongings				
Keeping work sites and accommodation place tidy and litter-free				
Using gloves when cleaning and working				
Having an assigned team of workers to do cleaning and housekeeping daily				
Having a proper refuse management system				
Washing hands regularly with soap and running water				
Limiting the sharing washrooms and belongings				
Wearing face mask always in public area				
Avoiding touching, hand shaking and hugging				

C7) What kind of health and safety control measures have you taken to avoid COVID-19 at sites and dormitories?

1 – Never use, 2 – Almost never, 3 – Occasionally/Sometimes, 4 – Almost every time, 5 – Frequently use

	Before COVID 19 Pandemic	During lock- down period	Immediately after lockdown period	Now
Controlling access and limiting contact with outside community				
Limiting workers movements & maintain social and physical distance				
Applying grid rules at site and dormitories				
Displaying adequate posters promoting respiratory hygiene				
Using disinfection chambers at the entrance				
Conducting awareness programs for workers regularly				
Introducing Sick reporting system and separate sick rooms				
Arranging Public Health Inspectors visits regularly				
Health screening and recording Covid19 Symptoms daily for each worker				
Disinfecting site office, dormitories, public places and equipment regularly				

C8) What are the procedures that workers had to follow when reporting back to work after lock-down period?

	Yes	Uncertain	No
Health screening and temperature monitoring			
Compulsory Isolation/self-quarantine for 14 days and closely monitor			
Conducting 1st PCR test within 2 days after return			
Conducting 2nd PCR test after 7 days of 1st PCR test			
Avoiding contacting with others for 14 days after self-quarantine period			
Applying entry and exist restrictions			

(C9) What are the procedures that Staff had to follow when reporting back to work after lock-down period?

	Yes	Uncertain	No
Health screening and temperature monitoring			
Restricting use of public transport			
Applying work from home concept			
Limiting working days and hours			
Introducing shift work			

(C10) What kind of challenges you have faced with respect to health and safety at the sites?

1 – Not at all a challenge, 2 – Minor challenge, 3 - Somewhat challenge, 4 – Moderate challenge, 5 – Serious challenge

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Unavailability/Higher Prices of PPE (face mask, hand gloves, hand sanitizers, etc.)				

Maintaining continuous food supply chain				
Difficult to find out health and safety guidelines/etiquettes related to Covid-19				
Educating workers about Health and Safety rules and regulation related to Covid-19				
Difficult to monitor and track workers				
Difficult to maintain health & safety practices while working				
Refusing workers for self-quarantine in isolation rooms				

SECTION C: WELFARE FACILITIES

(D1) How many numbers of workers are provided with accommodation facilities?

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Accommodation facility INSIDE the site				
Accommodation facility OUTSIDE the site				
NO accommodation facility				

(D2) If the dormitories are located inside the site, what are the main facilities provided?

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Providing Tea				
Providing Breakfast				
Providing lunch				
Providing Dinner				
Providing meal allowance				

(D3) If the dormitories are located outside the site, what are the main facilities provided?

	Before COVID 19 Pandemic	During lock- down period	Immediately after lockdown period	Now
Providing Tea				
Providing Breakfast				
Providing lunch				
Providing Dinner				
Providing meal allowance				
Providing transport facility				
Providing transport allowance				

(D4) What are the other facilities provided for workers who do not have dormitory facility?

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Providing Tea				
Providing Lunch				
Providing meal allowance				
Providing transport facility				
Providing transport allowance				

Reference: "Health and Safety Guidelines for Sri Lankan Construction Sites to be adopted during COVID 19- outbreak" - The Construction Industry Development Authority (CIDA)

(D5) What are the conditions of a dormitory room?

	Before COVID 19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Number of workers per room				
Number of single beds				
Number Double (Bunk) beds				
Number of Tables				
Number of chairs				
Number of Electric Fans				
Number of Air Condition Units				

(D6) How many workers shared the common facilities at dormitories?

	Before Covid-19 Pandemic	During lock- down period	Immediately after lockdown period	Now
Toilets and showers				
Kitchen/cooking area				
Dining area				
Washing/drying area				
Rest/Living area				

(D7) What kind of challenges have you faced with respect to welfare facilities of workers?

1 – Not at all a challenge 2 – Minor challenge 3 - Somewhat challenge 4 – Moderate challenge 5 – Serious challenge

	Before Covid-19 Pandemic	During lock-down period	Immediately after lockdown period	Now
Providing drinking water facilities to accommodation				
Providing required number of accommodation rooms				

Providing meals for workers				
Keeping workers in good mental condition				
Establishing and practicing health regulations and safety conditions at site/dormitories				
Providing required sanitary and washing facilities				

SECTION E: EMERGENCY AND DISASTERS

(E1) Have you experienced any Dengue outbreaks at your sites within last 5 years?

Yes	
No	

(E1a) Please provide details of Dengue outbreak?

	2020	2019	2018	2017	2016
Number of Dengue patients reported					
Number of deaths due to Dengue					
Location of Dengue patients reported					

(E2) Have you heard about COVID 19 before the outbreak in Sri Lanka?

Yes	
No	

(E2a) Please mention how did you hear about COVID-19?

Through TV/Radio News	
Through Newspapers	
Through social media	
Through the Internet	
From friends / society	
Other	

(E3) Have you expected this kind of pandemic situation in Sri Lanka?

Yes	
No	

(E4) What kind of preparation have you arranged in your sites to face emergency situations, disasters, and pandemics?

Preparation	Before Covid-19 Pandemic					Before Covid-19 Pandemic				
	Not at all concerned	Slightly Concerned	Somewhat Concerned	Moderately Concerned	Highly Concerned	Not at all concerned	Slightly Concerned	Somewhat Concerned	Moderately Concerned	Highly Concerned
Availability of Emergency action plan at the site										
Enhancing workers' awareness about how to act in an emergency										
Allocating key personnel for emergency control										
Establishing Emergency escape routes and assembly points at the site										
Availability of Siren for emergency situation										
Availability of Fire protection and firefighting facilities at the site										
Availability of Emergency and rescue equipment at the site										
Preparing Risk assessments and safe work procedures for all work activities										
Displaying Telephone Numbers of emergency contact agencies										
Conducting safety drills regularly at the site										

(E5) What are the guidelines and references you have followed to face Covid19 pandemic at site?

Guidelines and References	Never use	Almost never	Occasionally	Almost every	Frequently use
"Situation Reports" - Epidemiology Unit of Ministry of Health & Indigenous Medical Services					
Advice for high-risk country returnees" - Epidemiology Unit of Ministry of Health & Indigenous Medical Services					
"Public Advised Form" - Epidemiology Unit of Ministry of Health & Indigenous Medical Services					
"Novel Corona virus (COVID-19) advice for the public" – World Health Organization					
Operational guidelines on preparedness and response for Covid-19 outbreak for work settings" - Ministry of health and indigenous medical services					
"Guidance for workplace preparedness for COVID-19" - Epidemiology Unit Ministry of Health & Indigenous Medical Services					
"Health and Safety Guidelines for Sri Lankan Construction Sites to be adopted during COVID 19-outbreak" - The Construction Industry Development Authority - GOSL					

ANNEXURE – 2

National Registration and Grading Scheme for Construction Contractors

Registration and grading are a screening process continued by CIDA (Construction Industry Development Authority) for the capabilities of prospective contractors to determine their general ability to undertake different types and sizes of projects without reference to any specific contract. Registration and grading will be determined by evaluating a contractor mainly on his financial capability, the technical ability with staff and plant & machinery, and the experience gained in relevant fields.

Specialty	Grade	Financial Limit (Rs. Million)
Building Construction	CS2	$X > 3000$
Highway Construction	CS1	$3000 \geq X > 1500$
Bridge Construction	C1	$1500 \geq X > 600$
Water Supply and Sewerage	C2	$600 \geq X > 300$
Irrigation and Drainage Canals	C3	$300 \geq X > 150$
Dredging and Reclamation	C4	$150 \geq X > 50$
Storm Water disposal and Land Drainage	C5	$50 \geq X > 25$
Maritime Construction	C6	$25 \geq X > 10$
Heavy Construction (Areas to be Specified)	C7	$10 \geq X > 05$
	C8	$05 \geq X > 02$
	C9	$02 \geq X$