CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

Innovating Role of Lean Culture in Health and Safety Management at Construction Sites of Pakistan

by

Aown Muhammad

A thesis submitted in partial fulfillment for the degree of Master of Science

in the

Faculty of Engineering
Department of Civil Engineering

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This work is dedicated to all my valuable treasures in life, to my:

Respected Mother

who is my paradise and love:

Respected Father

who is my strength and life:

Thank you for always helping me through every difficult time of my life and for encouraging me to move forward. You have been always a sign of love and happiness for me.

and

Beloved Brothers & Sisters

who are very special to me.

CERTIFICATE OF APPROVAL

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Abstract

The construction industry is one of the main economic pillars of our industry. However, the record of Health and Safety issues in compliance with Occupational Safety and Health Administration (OSHA) Standards is not encouraging. So many projects suffer due to the issue of non-compliance with health and safety requirements. Ultimately, the projects are not only becoming uneconomical but also promoting the 3D Image (Dirty, Difficult and Dangerous) of this sector. Besides many other factors, the lean culture for OSHA implementations remains one of the major barriers. So, the study aims to investigate the role of lean culture in promoting and enhancing our safety standards. This would not only address the safety concerns but also give a handsome economic burden because of safety issues. To achieve the objectives, a critical literature review was performed to identify the health and safety risk factors.

Delphi technique was used to point out the important factors to be included in the research. Delphi process was concluded in three phases and different experts in the construction industry were requested to take part in this process. Based on the experience of the industry professionals, 65 factors were shortlisted which were further categorized in dimensions of lean culture and 6 latent variables i.e., lean leadership, teamwork, management role, social responsibility, working environment, and auditing and continuous improvement. A questionnaire survey was developed which was used to attain feedback from the different participants in the construction industry.

550 questionnaires were distributed, and 462 questionnaires were received back with a response rate of 84%. The reliability data was examined using SPSS which satisfied the significance level, ensuring the reliability data to proceed for further analysis. A normality test was carried out to assess the data pattern, resulting in a non-parametric pattern. By performing a one-way ANOVA test, the criteria for the perception level of the respondents in the parametric pattern was evaluated which remained about positive. Exploratory Factor Analysis (EFA) has been carried out to compare observed and identity matrix correlation of the dataset to ascertain any redundancy among the variable which can be summarized into

factors. To accurately examine the hypothetical relationship between observed and latent variables, Confirmatory Factor Analysis (CFA) has been done. In structural equation modelling (SEM), first and second-order CFA analysis has been performed using Amos graphics. To check the normality of each variable and accumulative normality of all variables, univariate and multivariate normality test has been carried out using Amos graphics. To validate whether there is any collinearity among the variables, multi-collinearity diagnostics have been done in SPSS. Then, correlation analysis has been performed in SPSS to find how much the variables correlate with each other. Lastly, to measure the strength of the relationship between variables, effect size analysis has been carried out in SPSS, followed by hypothesis testing.

Results supported twelve dimensions of lean culture, and a varying positive relationship of these dimensions with safety outcomes of lean leadership, teamwork, management role, social responsibility, working environment, auditing, and continuous improvement. Out of the twelve dimensions of lean culture, safety officer and supervisor, and safety policy had a strong association with all outcomes, safe working environment, safety awareness and safety standards had a moderate relationship, while safety incentives and safe activities and conditions had a limited influence. Results also supported the positive association between the second order composite form of lean culture and lean leadership, teamwork, management role, social responsibility, working environment, auditing, and continuous improvement.

This study contributes to the literature by highlighting the unique impact of specific dimensions of lean culture on outcomes. Data collection from private and public sector organizations also adds to the generalizability of results which is unlike in other studies. This study indicates various implications for the managers, such as by adopting safety policies, leaders can change employees' perceptions and motivate employees to exhibit positive behaviours. Further, safety matters for everyone, so managers can take benefit of these findings by adopting the aforementioned lean culture dimensions to shape employee behaviour to foster safety outcomes. Nonetheless, exploring these dimensions in another cultural setting may generate varying results. In addition to this study, future researchers are recommended to examine mediators and moderators and their influence on the nature of the relationship with different favourable and unfavourable safety outcomes. Nonetheless, future researchers are also recommended to further examine the impact of social distance and its unique influence on the relationship between lean culture and safety.

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Abbreviations

AC	Auditing and Continuous Improvement
ADF	Asymptotic Distribution Free
AGFI	Adjusted Goodness of Fit Index
AHP	Analytic Hierarchy Process
AMOS	Analysis of Moment Structures
ANOVA	Analysis of Variance
ANP	Analytical Network Process
BD	Biographical Data
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
COPD	Chronic Obstructive Pulmonary Disease
COVID	Coronavirus Disease
CR	Critical Ratio
DEA	Data Envelopment Analysis
EFA	Exploratory Factor Analysis
GDP	Gross Domestic Product
GFI	Goodness of Fit Index
GLS	Generalized Least Squares
HSE	Health and Safety Executive
ILO	International Labour Organization
JIT	Just in Time
KMO	Kaiser-Meyer-Olkin
LC	Lean Culture
LCF	Lean Culture Framework

LCHF	Lean Culture Hierarchical Framework
LL	Lean Leadership
LPDS	Lean Project Delivery System
MCDM	Multi Criteria Decision Making
ML	Maximum Likelihood
MR	Management Role
NFI	Normed Fit Index
NNFI	Non-normed Fit Index
OHS	Occupational Health and Safety
OLS	Ordinary Least Squares
OSHA	Occupational Safety and Health Administration
PCA	Principal Component Analysis
PGFI	Parsimony Goodness of Fit Index
PNFI	Parsimonious Normed Fit Index
PPE	Personal Protective Equipment
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RII	Relative Importance Index
RMR	Root Mean Square Residual
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Modeling
SGS	Société Générale de Surveillance
SPSS	Statistical Package for the Social Sciences
SR	Social Responsibility
SRMR	Standardized Root Mean Square Residual
TLI	Tucker Lewis Index
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
TW	Teamwork
ULS	Unweighted Least Squares
VIF	Variable Inflation Factor
VOS	Visualization of Similarities
WE	Working Environment

Chapter 1

Introduction

1.1 Background

Worldwide, the construction industry plays a critical role in the development process that generates additional demands for the construction industry [1]. It is regarded as one of the world's key industries, with $10 trillion in annual economic activity. Furthermore, the construction industry is a large industry that has had a big impact on other vital sectors such as transportation, education, and health owing to the need of creating infrastructure. By 2022, this industry is predicted to create 13% of the global Gross Domestic Product (GDP) [2]. The 'Construction 2025' industrial strategy paper produced by the UK Government between 2013 and 2025 predicted a 70% increase in this industry [3]. The contribution of the construction sector to the GDP of Pakistan decreased since FY19 from 3.8% to 2.8% due to the pandemic of Covid-19, **Figure 1.1** [4].

However, the industry is still known as one of the most potent components of the industrial sectors of the country [5]. It is particularly critical in industries with outmoded linear economic consumption and production models, as well as wilful and purposeful misunderstanding of the importance of employing professional safety measures, such as construction [6]. Safety on construction sites is a major problem in both developed and developing countries [7]. Construction is a complex operation involving many stakeholders continuously challenged by the job's needs. Each project experience several safety and risk issues, necessitating the implementation of quality and safety management systems [8].

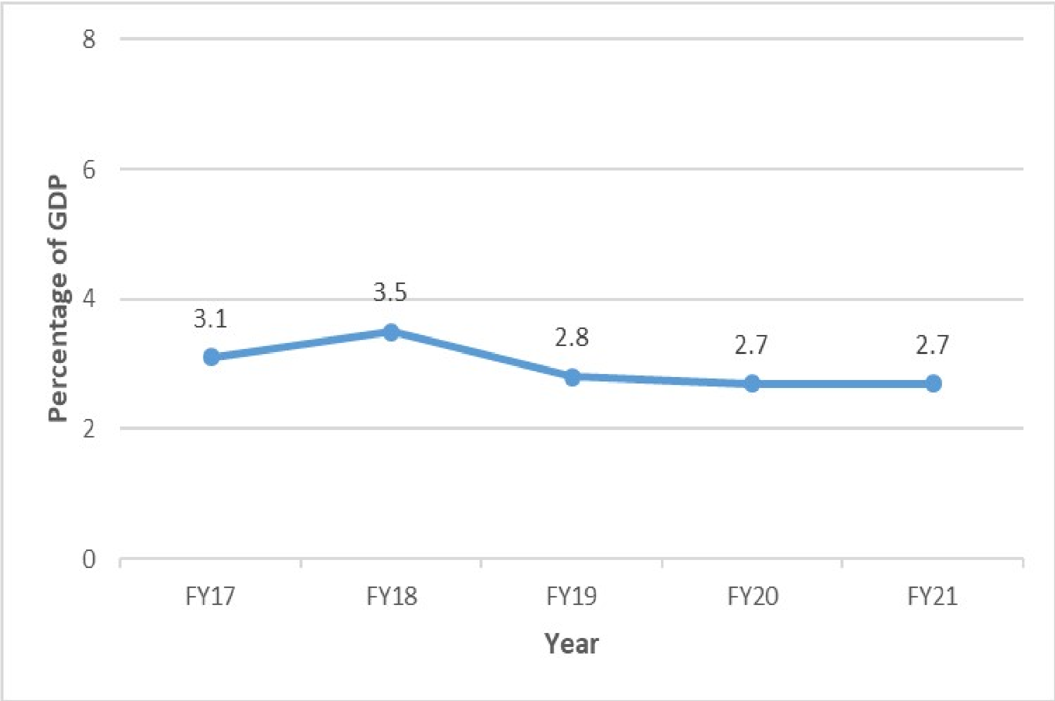
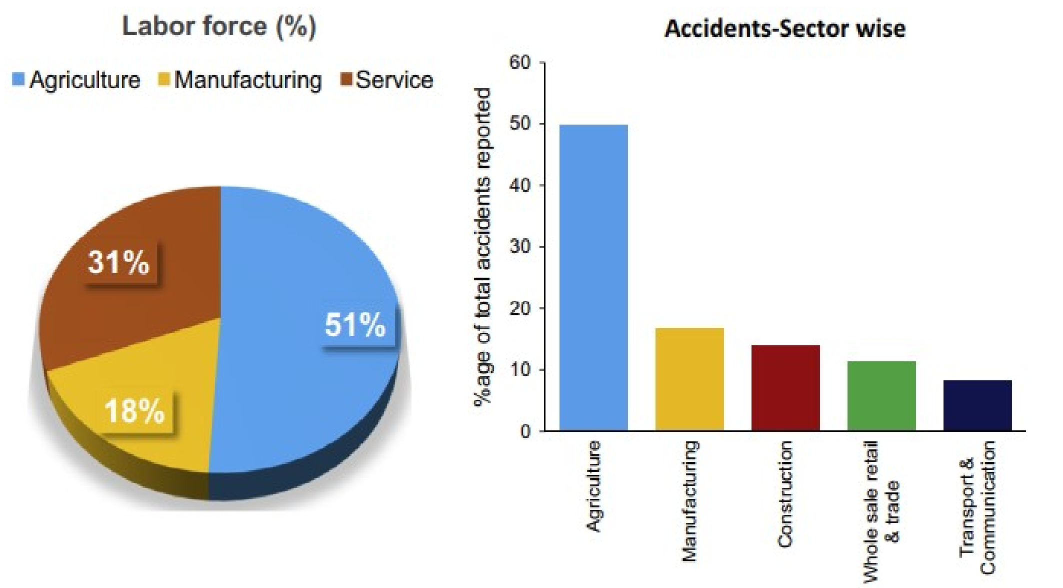


Figure 1.1: Construction Sector % Gdp of Pakistan [4]

In most cases, safety measures will cost a specific amount of money, whereas injury costs are only incurred if an event happens. However, injury expenses will be high, and when there is a strong emphasis on safety, injury occurrence will be low [9]. The scope of the project involves large human resources on the job sites. The presence of a large population in workplaces where the chances of accidents due to falls, lifting, and other related activities are higher exposes them to a higher risk of encountering incidents that cause widespread damage to the population. Unexpected workplace catastrophes can occasionally be caused by poor working conditions. Due to poor reporting and distortion of work-related accidents and illnesses, including fatalities, reliable documentation of occurrences is difficult. However, the International Labour Organization (ILO) estimates that 2.78 million people worldwide die each year because of work-related accidents and illnesses. There are approximately 374 million non-fatal workplace injuries yearly, with a four-day absence from work. Construction appears to have a disproportionately high rate of workplace accidents compared to any other industry worldwide [7]. Therefore, health and safety management is the foremost priority in the case of the construction industry as this industry is more likely to experience fatal injuries. Despite rapid growth in technological advancements, construction workers are still experiencing poor safety conditions. Thus, this aspect is one of the most concerning factors for policymakers and governments. According to the International Labour Organization, occupational injury can be defined as an injury or sudden accident which leads to an extremum of death due to a work-related mishap [10].



(a) Distribution of total labor force (b) Accidents relative to reported injuries/diseases

FIGURE 1.2: Rate of Occupational Injuries in Pakistan [11]

This type of injury is unintentional and inadvertent. Based on a global report it has been found that there are more than 374 million nonfatal occupational injuries that take place annually. Based on the survey report by the labour force, around one-tenth of the labourers belong to Pakistan and the report also indicates that the labour force of Pakistan is highly prevalent in construction work-related mishaps. Additionally, around 16% is attributed to construction. The prime reason behind this higher prevalence of work-related injuries is a precarious position without taking proper gear and carelessness, **Figure 1.2** [11]. Moreover, slippery surfaces and the utilisation of defective tools and equipment also contribute to the risk of injuries.

Health and safety management in construction industries is one of the most prioritised aspects as it is a multi-step procedure associated with maintaining the health and safety conditions of the construction site workers, nearby people, managers, and supervisors. The workers are more prone to experience falling due to slippery surfaces, therefore; measurement regarding fall prevention is considered one of the prime necessities for this industry [12]. Moreover, the construction workers should also be informed about the site hazards and control measures to avoid risks. For this reason, the provision of welfare facilities and effective suture rules and guidelines can be able to mitigate the risk of work-related mishaps in this industry.

As the construction industry is more prone to experience accidentally, therefore, it has been emphasized to opt out of health and safety management protocols by SGS (Société Générale de Surveillance) which includes suggestions related to avoidance of accidents before they manifest, coordination of health and safety projects upon complying with HSE (Health and Safety Executive) construction regulations [13]. This is because the construction industries which are also referred to as high-risk possess a significant impact on the health and safety conditions of the workers as construction work-related injuries are plagued by poor working conditions and significantly dangerous situations. In 2017-18, 2.7 million employed people got injured at work in Pakistan [14].

In this regard, ILO has focused on aiding the Pakistan government in terms of implementing several interventions related to health and safety measures for construction workers. The major challenges of construction industries in the context of health and safety measurements include working at heights, scaffolding issues, and excavation work as well as trenching at construction industries. In addition to this, risks related to housekeeping due to slippery surfaces, the presence of loose objects on stairs, platforms, and floors can also contribute to health hazards for the workers. The scaffolding issues are one of the most concerning issues in the case of the construction industry as improper scaffoldings result in fall hazards [15].

Moreover, failure to use protective equipment and essential accessories also contributes to the experience of fatal accidents on construction sites [16]. Safety culture is crucial to construction; particularly given the construction industry is notorious for its poor safety records. Safety culture is becoming critically important to the safety of employees within the construction site environment. A major shortcoming with most safety culture models is the lack of integration into general organizational culture models. Although it has been widely used for many years, the concept of safety culture is not precisely clear [17]. In terms of mitigating the risk of health hazards in the construction industries, the lean culture combined with the safety aspect can be able to improve the safety culture of the construction industries to a great extent [18]. The concept of lean culture is associated with driving better results upon taking a systematic approach related to the implementation of several controlling measures to mitigate the risk of work-related injuries and illness [19]. The lean culture is concerned with six factors which include sort, strengthen, standardize, shine, sustain, and safety. The first aspect is associated with sorting the working areas upon removing obstacles that may cause accidents.

Following this, the aspect of strengthening is associated with the utilisation of proper tools and equipment as improper handling of equipment may cause the serious threat of injuries. Other aspects such as shine, sustain, and standardize are associated with ensuring the workers follow safety guidelines related to health and safety [20]. Therefore, the lean culture aims for fostering continuous improvement for a safe workplace so that the risk of health hazards due to accidents and injuries can be minimized significantly.

1.2 Research Motivation

Even though the construction industry significantly contributes to the country's economic success, numerous accidents have led to a high death rate [1, 21]. In many countries, construction is far more prone than any other business to cause deaths and accidents [21-23]. According to Demirkesen [21], in the United States, there were 5190 fatal work injuries documented, with 991 of them happening in the construction industry. In the preceding five years, the construction industry in Vietnam had the same general prevalence, with 20% – 38% of work-related deaths and 20% – 36% of work-related injuries [23]. Construction-related injuries and accidents are 50% greater than in any other industry in the United States; they account for 40% of all accidents in Japan, 50% in Ireland, and 25% in the United Kingdom. In underdeveloped countries, the situation is significantly worse. The Middle East has an occupational fatality and injury rate of 18.6 per 100,000 employees, compared to 4.2 per 100,000 in industrialised nations. Previous research has linked developing countries' low safety performance to a lack of strong safety and building laws, high rates of unskilled immigrant labour, and unemployment [22]. Regarding Pakistan, 2.7 million of the employed labor (61.7 million) experienced an injury at work in 2017-18. Out of them, 467,100 people (17.3%) were related to construction sector [24]. Therefore, it is most urgent for the construction sector to devise effective strategies related to health and safety concerns and address the dangers to life in a sustainable manner.

1.3 Problem Statement

The construction industry is one of the main economic pillars of our industry. However, the record of Health and Safety issues in compliance with Occupational Safety and Health Administration (OSHA) Standards is not encouraging. So many projects suffer seriously due to the issue of non-compliance with health and safety requirements. Ultimately, the projects are not only becoming uneconomical but also promoting the 3D Image (Dirty, Difficult and Dangerous) of this sector. Besides many other factors, the lean culture for OSHA implementations remains one of the major barriers. So, it is very important to investigate the role of lean culture in promoting and enhancing our safety standards. This would not only address the safety concerns but also give a handsome economic burden because of safety issues. In terms of providing health and safety measures for the construction workers, Pakistan has focused on enacting the act of Labour policy 2010 which has proposed the extension of the compensation act of the workmen's 1923 which provides compensation in the case of any injuries for the construction workers [11]. Additionally, the Pakistan government has implemented Labour Policy 2018 along with the ILO conventions [25]. In this regard, this study is going to analyse the role of lean culture in the context of health and safety management of construction workers.

1.4 Research Questions

The focal point of this research investigation is to empirically examine the twelve dimensions and the composite model of lean culture and to examine their influence on outcomes. Therefore, this research study attempts to answer the following research questions:

Research Question 1

What is the impact of the twelve dimensions of lean culture, i.e., safe working environment, safety officer and supervisor, reduced health and safety hazards, safety training, safety commitment, safety incentives, safety inspection and monitoring, safety awareness, safe activities and conditions, safety concerns, safety policy and safety standards, on outcomes, i.e., lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement?

Research Question 2

What is the relationship of the twelve dimensions of lean culture with lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement, and which dimensions of lean culture work strongly?

Research Question 3

What is the impact of the composite form of lean culture on outcomes, i.e., lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement?

1.5 Objectives of the Study

This study extends the research on lean culture to explore the concept of lean culture and how lean culture and its twelve dimensions impact outcomes, i.e., lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement. This study also provides the opportunity to empirically examine the earlier relational traces examined, to be analysed in the public and private sector organizations in Pakistan. Therefore, the objectives of this study are listed below:

Research Objective 1

To investigate the relationship of twelve dimensions of lean culture, i.e., safe working environment, safety officer and supervisor, reduced health and safety hazards, safety training, safety commitment, safety incentives, safety inspection and monitoring, safety awareness, safe activities and conditions, safety concerns, safety policy and safety standards, with lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement.

Research Objective 2

To identify the impact of composite lean culture on lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement.

1.6 Scope of Work

Scope of the work includes the identification of all those factors which play their role in implementing lean culture for lean construction. The variables related to health and safety management in the construction industry are identified as well. Common factors in both areas are extracted with the help of practitioners and academicians related to construction management. In the end, feedback analysis has been performed using the Statistics tool SPSS (Statistical Package for the Social Sciences) and Amos (Analysis of Moment Structures) Graphics.

1.7 Study Limitations

This study has some methodological strengths that enhance the overall confidence in the results, but despite this, this study is not without limitations. The data collection only records the response of the individual employee and staff working on construction projects. Therefore, this study has a limitation in that it only considers the opinions of employees about lean practices. The data collected was from four major cities in Pakistan from private and public sector organizations. Therefore, the generalizability of the results across industries may require additional investigation. Furthermore, the sample size was only limited to private and public sector organizations; other industries may experience a different demonstration of lean culture by the managers.

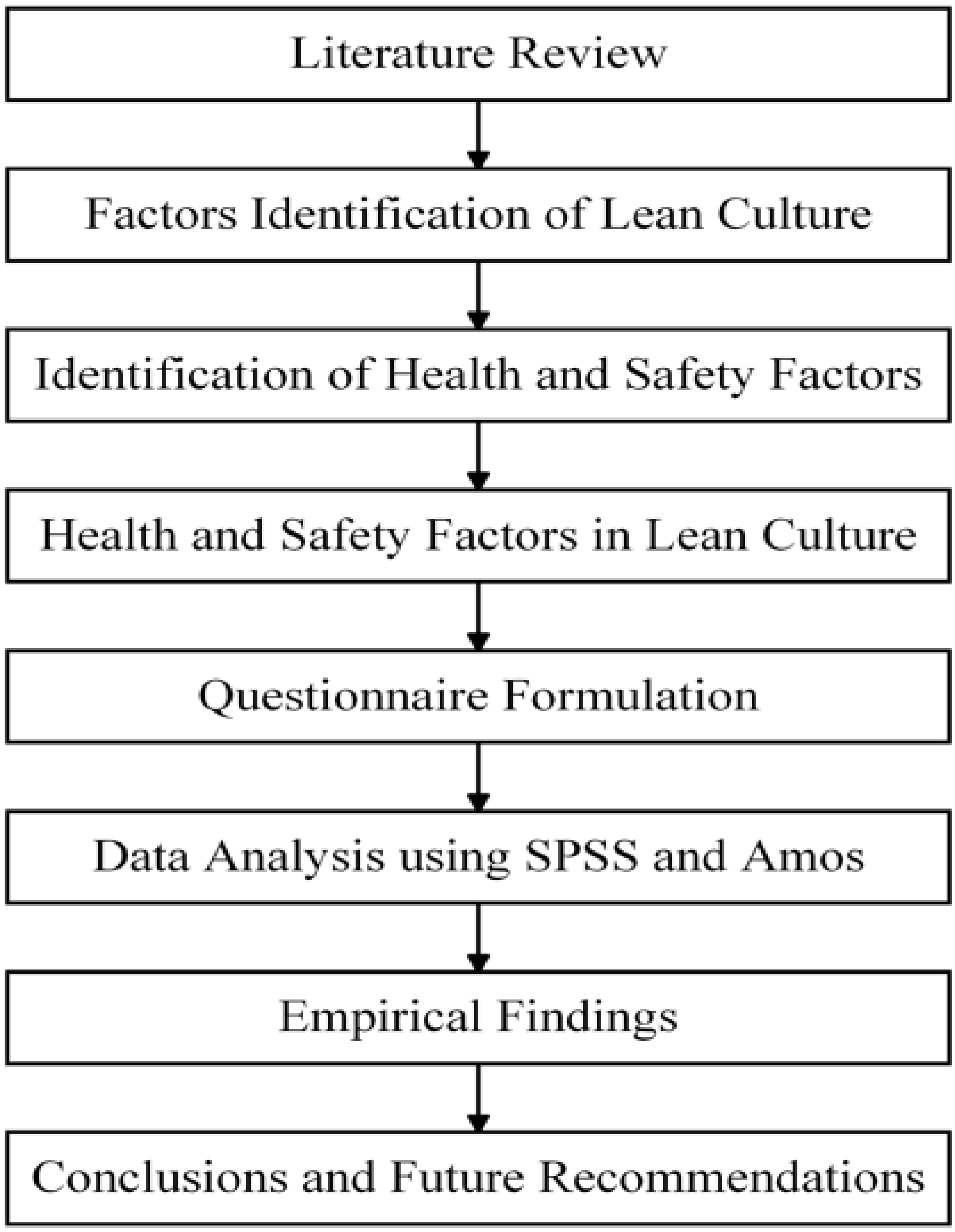


FIGURE 1.3: Methodology of the Research Work

1.8 Brief Methodology

The stepwise methodology being conducted is shown in **Figure 1.3**. For the literature review of the research work, articles were searched using the keywords "lean construction", "lean culture", "construction safety", "lean safety" and "lean culture for health and safety" on Google Scholar, ScienceDirect, ResearchGate and Taylor and Francis platforms. More than 300 journal articles, conference papers, thesis and books were found. After reviewing all of them, factors affecting safety performance in traditional and lean organizations' cultures were achieved. Using the Delphi technique, a questionnaire was developed.

The questionnaire was sent to practitioners of the field. After getting the response, the data was analysed using a statistical tool SPSS and Amos graphics so that empirical findings could be noted down. In the end, conclusions were drawn and some recommendations for future research were presented as well.

1.9 Thesis Outline

This thesis contains five chapters which are presented in a way that readers can get a clear understanding of its progress. They are summarised below:

Chapter 1 – Introduction, details about the background of relevant study, motive and research objectives being forwarded by scope and limitation of the work. In the end, a brief methodology is presented.

Chapter 2 – Literature review, compiles of introduction, safety and culture of construction industry being driven by lean culture and identified research gap.

Chapter 3 – Methodology, gives detail about the adopted methodology to conduct the research work.

Chapter 4 – Results and discussions, presents real-life data based on questionnaires and interviews conducted with industry practitioners and academicians.

Chapter 5 – Conclusion and recommendations, shows concluding points on the base of a complete analysis. Recommendations for future research work are summarised as well.

Chapter 2

Literature Review

This chapter provides the theoretical context for the analysis by examining the relevant literature on regulatory frameworks. This context would identify and highlight the aspects with an emphasis on lean culture and its impact on health and safety management. This is an evaluative report of the knowledge recorded in the specific areas.

2.1 Introduction

In lean construction, the production systems are designed in such a way that maximum value can be generated by minimizing waste whether it is coming from materials, effort, or time. Besides, it helps significantly in improving trust among all stakeholders. Teams' collaboration is encouraged in the search for tools and ways that can eliminate waste at the worksite. Lean culture also plays an important role in improving safety for workers and employees at construction sites. However, the application of lean construction attributes for construction site safety remains limited especially for lean culture. Any human activity which is using resources and not creating any value is considered waste. Lean construction has eight major aspects which are lean leadership, lean planning, lean concept, lean thinking, lean tools, lean safety, safety culture and lean culture [21, 26-28], which can be seen in **Figure 2.1**. These aspects have the ability that safety performance and safety standards can be greatly improved.

Because of the risky nature of the construction industry, it must face severe safety issues including numerous fatalities and accidents occurring at worksites. Similarly, the compensation rates for accidents in the construction industry are higher than those of any other industry [21].

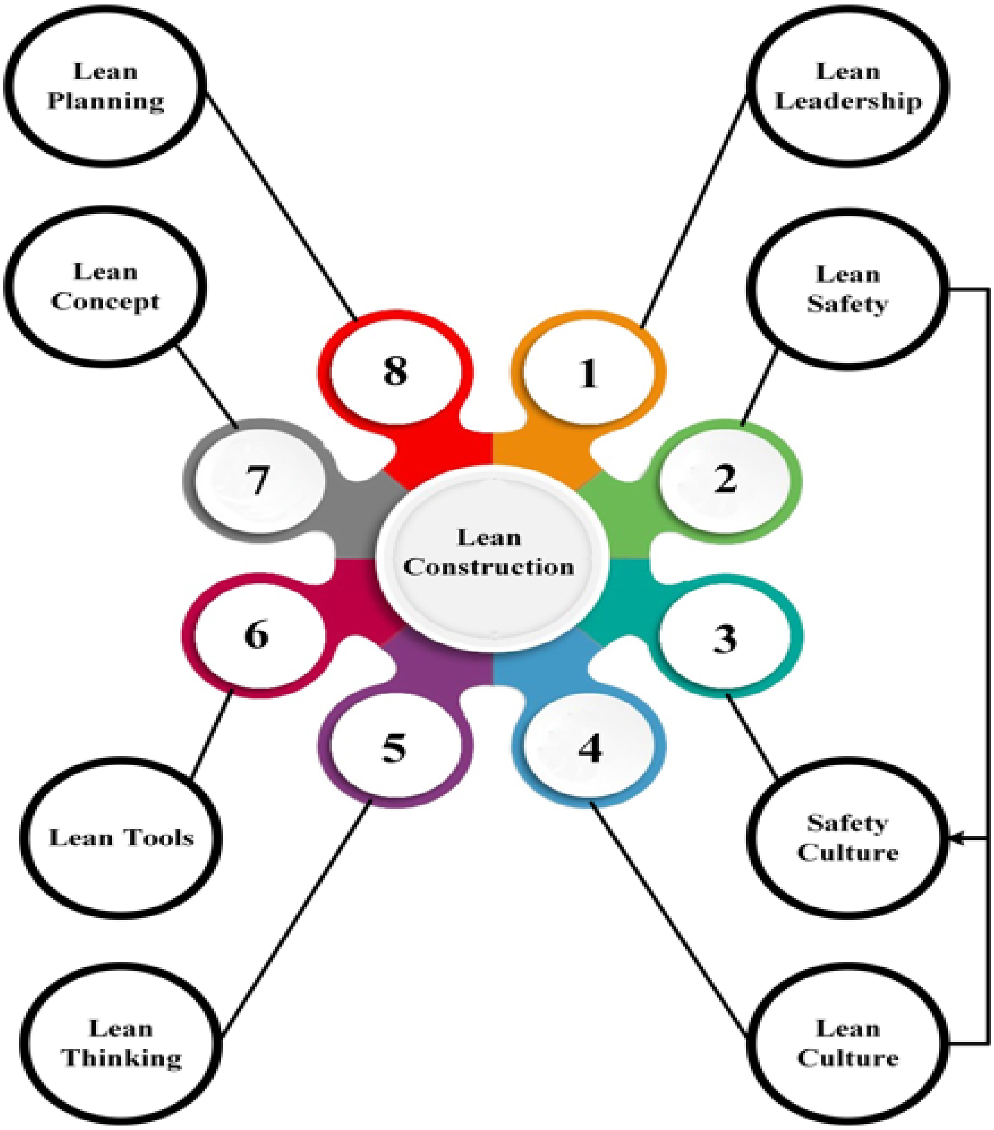


FIGURE 2.1: Lean Construction [21, 26-28]

The major cause of accidents in the industry is due to its unique nature, human behaviour, insecure work methods, inappropriate site conditions and tools which are affected by the absence of strong safety management. So, it is the responsibility of the employer to make training available for all employees and the implementation of safety programs which improves safety performance to minimize or eliminate hazards and risks at project sites [1]. Lean culture also plays an important role in improving safety for workers and employees at construction sites. However, the application of lean construction attributes for construction site safety remains limited especially for lean culture.

Lean culture is considered a customer-focused learning culture which is dedicated to continuous improvement [29]. Usually, the different pillars of lean culture are described by these distinctive dimensions: cultural enablers, enterprise alignment, continuous improvement and consequences enhancing safety performance and creating value for the customers [30]. Although various tools for safety performance have been provided by many researchers, they do not provide a clear approach for its enhancement and some of them are complex enough that they cannot be implemented practically [7, 31-35]. Thus, an effective strategy in this regard is still lacking in the industry which can be attained through appropriate exploring the innovative role of lean culture in health and safety management at construction sites.

As it is dependent on the researchers' tastes, papers selected manually are sometimes biased. As a result, in addition to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) research, a computational analysis that examines relationships and enables for visualisations of citation networks should be employed [36]. This review paper presents a scient metric study technique employing the VOS (Visualization of Similarities) viewer, which is often used to analyse publication networks and link to the topic of inquiry. The illustrated bibliometric network can be built using citation, bibliographic coupling, co-citation, and/or co-authorship. Text mining, for example, may be used to generate and visualise co-occurrence networks of significant terms retrieved from a corpus of scientific literature [37].

Keywords are the fundamental topics covered in research papers [38]. As a result, a network representation of keyword re-occurrence was built, and the results are displayed in Fig. 2.2 in what seem to be the most significant nodes of the research flow, demonstrating links between lean culture and construction health and safety management. The link between these terms reveals the literature recurrence rates. The figure's node density depicts a study's greater degree of citations, while the node links depict citations in pair and group articles. These connections become stronger if two neighbouring nodes have similar co-authors or often pair citations (closer nodes) [39]. The formation of five related domains to lean culture and safety, including health, safety, lean implementation, culture, and construction firm, was revealed after further study of network nodes. The node appearances in Fig. 2.2 are influenced by the search criteria, but the links are not.

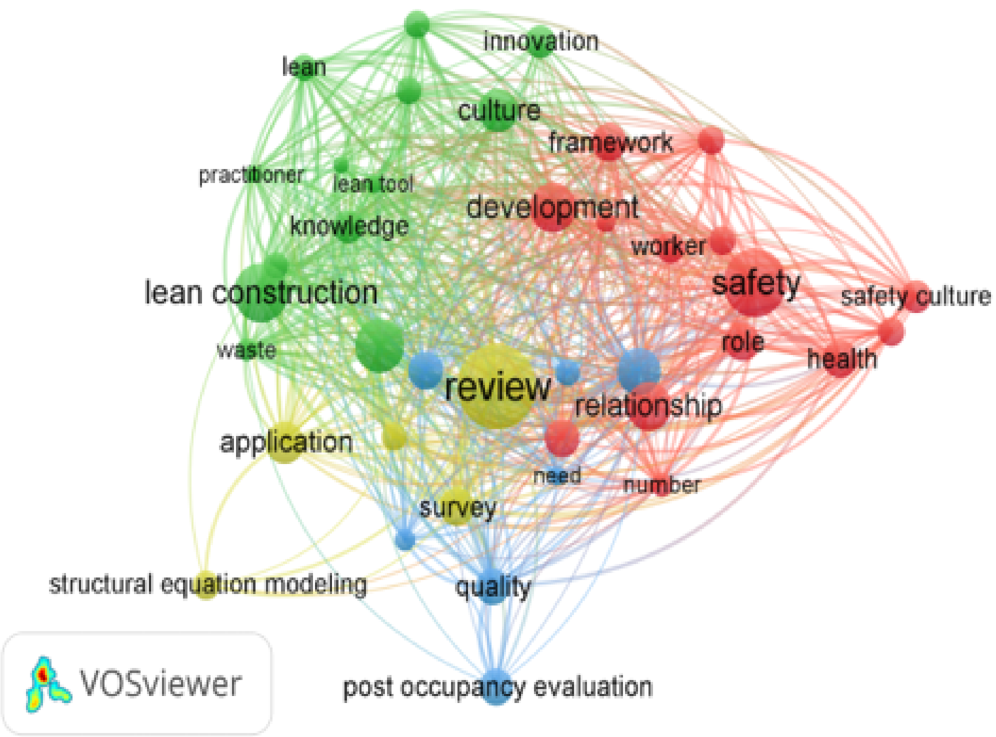


FIGURE 2.2: Analysis using VOS Viewer

2.2 Construction Industry

The architecture, engineering and construction sector is one of the most profitable industries in the world since it contributes to economic growth. This industry makes a considerable contribution to the world economy. There is no doubt that the industry is important for the prosperity of any nation [2]. The construction industry is more prone to experience work-related mishaps; therefore, several safety-related conditions can be able to minimize the degree of risks due to injury in construction industries [40]. The major risks of construction health and safety aspects include working at height, moving objects, collapses, slips, trips, falls, vibrations, and asbestos [41]. However, poor health and safety measures implementation may give rise to the prevalence of health hazards due to injury. In this regard, the safety conditions include wearing PPE (Personal Protective Equipment) for the construction site workers as safety boosts better grip and protects feet [42]. Induction of the construction sites as every site possesses unique hazards and operations so that provision of proper suite information is the regulatory requirement for the workers [43].

Following this, cleanliness is another major aspect in the case of construction industries as slips and trips are the major issues that may cause falling [44]. Based on HSE statistics, it has been found that slips and trips cause 30% of injuries on construction sites. Additionally, working in safe construction sites is another prioritised aspect in the case of the construction industry. In this context, based on the HSE statistics it has been found around 14% of health hazards are caused due to something collapsing or overturning, and 11% of the insurers are caused due by struck during the movement of vehicles [45]. Therefore, safety guidelines for safe construction sites are one of the most important conditions in the case of construction industry.

2.3 Role of Safety in Construction Industry

For a long time, the construction sector was regarded as the riskiest, with numerous accidents. Construction site incidents or accidents have had a range of negative repercussions on project performance, including project delays, higher project costs, lost productivity, and bad impressions of the organisation. As a result, maintaining workplace safety and health is vital for companies to avoid accidents. Providing essential training to the workers and encouraging a friendly environment at the worksite helps in boosting their confidence and making them compliant with safety [7]. Workers' behaviour, working atmosphere and management practices are considered as main antecedents of occupational health and safety (OHS) performance [46]. With ages, OHS management has evolved with new factors considering technical, cultural and human factors etc [23]. Lagging indicators are conventional methods for the measurement of safety performance and these have been replaced by leading indicators which are safety planning, incident inquiry, leadership commitment to safety culture, safety training, bonus and rewards system [47]. Safety training, the installation of a safe working environment, and the adoption of safe plant and equipment are among the most widely cited factors impacting construction project safety performance at the project level [1].

Construction is a risky sector to work in. As a result, important safety measures to mitigate risks and assure project safety must be established. Modern safety applications, however, have yet to be developed, despite the growing prevalence of workplace accidents [21]. Employers can avoid indirect costs associated with workplace incidents by implementing a health and safety programme, such as lost time as a result of work stoppages and investigations, training and other costs associated with replacing injured workers, as well as material, machinery, and property losses or damage. These indirect expenses are at least 2.7 times the direct costs, according to estimates. Safety plays its role in construction in major five key areas [48]:

Reduces/ avoids the cost of human suffering:

a. Physical pain and suffering caused due to death or disability is impossible to measure

b. Inability to measure the disruption in the lives of workers and their family

i. Boosts/ strengthens the workers' morale

a. Morale weakened by safety accidents

b. Morale is strengthened by rigorous training programs to avoid such accidents

ii. Avoid legal actions

iii. Avoid financial burdens (direct and indirect)

a. Compensations, damages (direct)

b. Delays, claims, overtimes, fines (indirect)

iv. Advantage for gaining new joint ventures

a. Better safety record always beneficial

2.4 Safety Issues in Construction

There are many safety issues at construction sites, some of them are mentioned below:

2.4.1 Hazards

2.4.1.1 Ergonomic Hazards

An ergonomic hazard is a physical component in the environment that harms the musculoskeletal system. Ergonomic risks include topics like repeated movement, manual handling, workplace/job/task design, uncomfortable workstation height, and incorrect body location [49].

2.4.1.2 Behavioural Hazards

The behavioural hazards are referred to as the habitual practice of the workers related to not using safety equipment while performing any tasks. This type of hazard is associated with the tendency of the workers to not use the latest equipment because their attitude towards the latest equipment is irrelevant and unnecessary to use while performing any operations. Therefore, this hazard is chiefly related to the attitudes toward not using updated equipment and accessories. However, the utilisation of outdated equipment may contribute to health hazards for the construction workers. In this regard, the construction industries are required to educate the workers regarding the utilization of the latest equipment as mental resistance towards the incorporation of the latest accessories in the operations may lead to serious health hazards for the workers [50].

2.4.1.3 Physical Hazards

"An element in the environment that, with or without touch, may hurt the body," is defined as a physical hazard. It also includes electricity, radiation, pressure, noise, heights, and vibration, to name a few [51].

2.4.1.4 Chemical Hazards

A hazard is when construction personnel are exposed to dangerous chemicals. Chemical exposure at work might have immediate or long-term harmful health repercussions [52].

2.4.1.5 Biological Hazards

A biological hazard is one that a biological organism or a material produced by such an organism presents to humans. The hazard might be direct, such as infection, or indirect, such as environmental damage [53].

2.4.1.6 Radiological Hazards

This type of hazard is caused due to utilization of radioactive chemicals such as thorium which is used in building materials. Exposure to high levels of radiation can be responsible for causing serious health hazards for construction workers especially skin burns and acute radiation syndrome which may further because long-term health hazards such as cancer and cardiovascular diseases [54].

2.4.2 Accidents

The more common accidents which take place during the construction include falls from the height such as scaffolds, ladders, and rooftops. Additionally, collapsing of grounds or trench, falling of construction debris, electrocutions, slip and falls, explosions or burns, and accidents from machinery activity are the most occurring and concerning accidents that take place on construction sites [55].

2.4.3 Unsafe Acts

Unsafe acts may be defined as the activity by the construction workers which are not included in the safety standards but still, these actions are performed. This may cause accidents and serious health hazards for the workers. In the case of the construction worker, they are prescribed to wear PPE for better gripping and protection of feet. However, if any worker does not follow this safety guideline, they might face severe accidents during the construction operation. Additionally, using sharp equipment at unsafe speed may also lead to severe injuries for the construction workers. Moreover, improper knowledge of equipment handling and using outdated equipment may increase the risk of accidents on construction sites [56].

2.4.4 Unsafe Conditions

The conditions related to construction industries that possess severe risks include conditions such as slippery surfaces, unguarded excavations, or floor openings, working on lines without proper safety measures, improper earthing, constrained location, exposed live wires, and inappropriate illumination. These types of conditions may pose severe risks for the construction workers on the construction sites [57].

2.4.5 Secondary Causes

2.4.5.1 Management Systems

In the case of the construction industries, the construction managers are highly responsible for implementing several safety guidelines for the construction workers upon considering the prescribed safety protocols related to the health and safety management of the construction workers. Moreover, the management system is associated with the provision of proper training based on the handling of equipment, wearing PPE, and the methods of eliminating hazards. However, lack of management and improper training of the construction workers may lead to severe accidents of the construction workers. Additionally, the construction management system is also associated with dealing with both the physical and psychological well-being of the workers as the construction industry is more likely to experience severe injuries and stress as well as anxiety due to heavy work pressure. Therefore, improper management systems can be responsible for contributing serious heat hazards to the workers [58].

2.4.5.2 Social Groups

Collaboration among the workers leads to the willingness of the construction workers to perform optimally and it also enhances the value of the construction industry. Due to heavy workload, the construction workers often are more likely to experience mental burnout, therefore; lack of collaboration may lead to impact negatively on the work performance of the workers. Moreover, collaboration improves the quality of the work and fosters timely project completion. However, lack of collaboration often leads to project delay, and this creates mental stress, depression and anxiety for the workers [59].

2.5 Role of Culture in Safety

Work safety culture in an organization is strongly influenced by the dimensions of work safety culture in the organization. There are 10 dimensions of work safety culture in state-owned contractor companies. Likewise, the results of research, dimensions of work safety culture in national private contracting companies have 10 dimensions. The cultural dimensions of the contractor's company (state-owned and national private sector) based on the research results there are leadership, contract systems, workers, labour, policy, the value adopted, strategy, costs, processes, and behaviour [60-62] as shown in **Figure 2.4**.

2.5.1 Pathological

According to this culture, individuals cause accidents and injuries, and this culture is chiefly concerned with the reinforcement of mandatory regulations related to health and safety management. Moreover, this type of safety culture is chiefly associated with the implementation of several safety guidelines and health as well as safety programmes so that improved safety systems can be promoted in the industries. This type of safety culture is responsible for avoiding any kind of prosecution upon implementing effective health and safety programmes for the workers [17, 63-67].

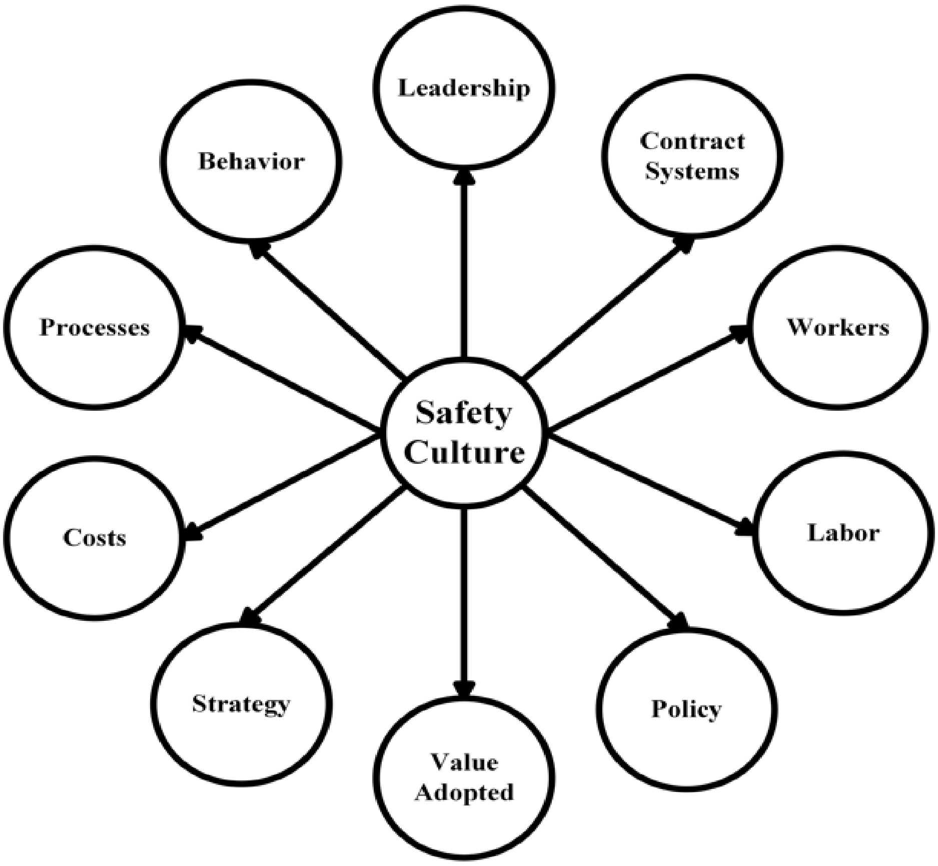


FIGURE 2.3: Safety culture [60-62]

2.5.2 Reactive

This type of safety culture considers the aspects of health and safety as one of the most important aspects in the context of the low-level workers who are more prone to accidents. Therefore, in the case of the construction industries, this type of safety culture is useful as it is associated with the implementation of several health and safety-related guidelines in terms of improving the safety culture of the industries. This type of culture uses both the organisational and individual health and safety management techniques so that organisational safety culture can be enhanced effectively [17, 63-67].

2.5.3 Calculative

This type of safety culture is chiefly concerned with valuing the system related to health and safety performance along with the utilisation of various skills and techniques. As the safety culture is chiefly based on valuing the individual and group's health aspects therefore this type of safety culture focuses on analysing metrics and utilising various techniques in terms of provision of training to the workers so that they are well aware of safety guidelines [17, 63-66].

2.5.4 Proactive

According to this safety culture, the aspects of health and safety are the core values where it underpins the concerns of the management groups and leadership teams towards the workers. This culture chiefly concerns the well-being of the workers upon mitigating the risk of incidents and accidents by educating the workers. Moreover, this culture is associated with simplifying the work processes so that work pressure can be reduced [17, 63-67].

2.5.5 Generative

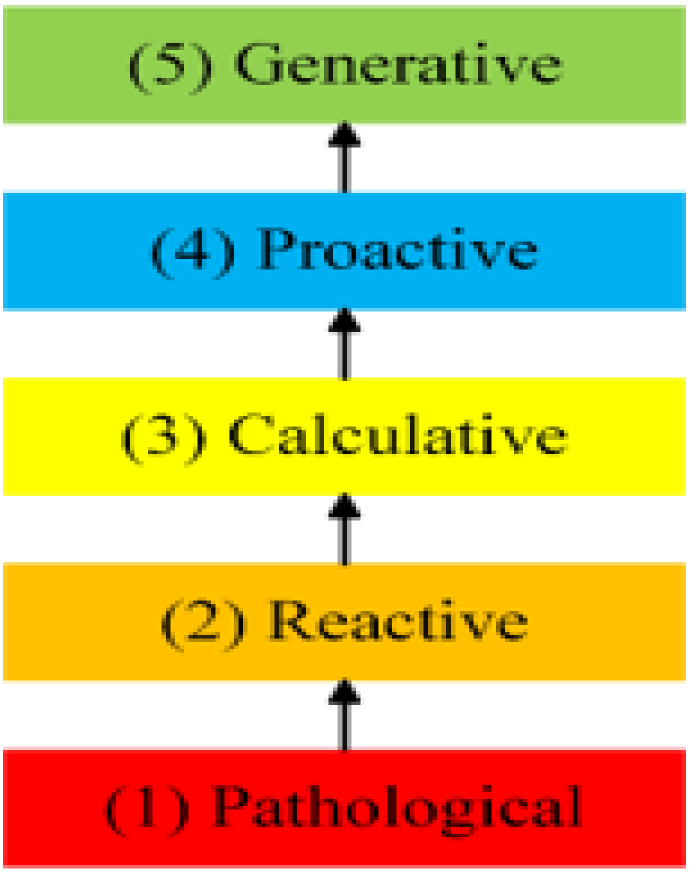


FIGURE 2.4: Typology of Organizations [68, 69]

This type of safety culture is concerned with the benefits of the health and safety management of the workers upon focusing on daily monitoring of the health of the workers. Based on a recent report of Pakistan it has been found that this country is progressing towards zero accidents in the occupation sites and the rate of accidents has declined up to 8% in 2019. Additionally, 44% of lost-time accidents have been reduced in Pakistan among the contractors upon focusing on the safety culture. In this regard, this country has focused on a cultural change programme upon implementing lifesaving rules for the workers [17, 63-67]..

Typology of organisational was proposed by Ron Westrum [68, 69]. Westrum's model distinguished three types of organisation – pathological, bureaucratic and generative. This model was extended from three to five stages in sequence, replacing the label 'bureaucratic' with 'calculative' and introducing two extra stages, the reactive and the proactive stages [70, 71] as shown in Fig. 2.4. This was done to allow for more subtle and accurate classification, and at the same time increasing the accessibility of the framework to industry employees by including terms they would be familiar with [72].

2.6 Lean Culture and Safety

Lean culture enables workplaces safe for employees through lean tools and lean leadership. In lean culture, a company uses its resources on a program which actively improves safety and minimizes direct and indirect safety costs instead of spending its resources on compliance-based safety programs. One of the major responsibilities of lean leaders to engage their employees is to consider them as an asset not cost. This culture engages employees through building trust. As a company's progress depends on its employees so lean leaders spend their time engaging them and increasing their skills through various strategies and one of them is safety [19]. Safety is improved through essential activities of continuous improvement without affecting safety programs [73].

The major issues related to construction industries in the context of health and safety management include risks from electricity, hazards from airborne fibres and toxins which cause serious lung disease and even death of the workers, mental burnout due to excessive work pressure, inhalation of isocyanates present in the building insulation materials which may lead to asthma, silicosis, and COPD (Chronic Obstructive Pulmonary Disease) of the workers. Additionally, asbestos is another key substance in deteriorating the functionality of the lungs [74]. Moreover, unintended falls due to scaffold issues or excavation issues are also a major issue in the case of the construction industries which may foster serious health hazards for the workers and even death [75]. In terms of mitigating these issues, implementation of lean culture can be considered one of the most effective strategies as it aims for improving the safety culture of the industries. The main purpose of lean culture in the context of health and safety management is to maintain the safety protocols such as cleanliness equipment handling procedures on the construction sites, and implementation of preventive maintenance activities [76]. According to the concept of this culture, the chances of change increase with the focus on safety in terms of transforming the safety culture of the industries.

2.7 Dimensions of Lean Culture

A total of 21 dimensions of lean culture were collected from the literature review which is shown in **Table 2.1**.

2.7.1 Factors Affecting Lean Culture for Safety

Following dependent variables have been scrutinized which have a deep effect on lean culture for safety.

a) Lean Leadership,

b) Teamwork

c) Management Role

d) Social Responsibility

e) Working Environment

f) Auditing and Continuous Improvement

Table 2.1: Dimensions of Lean Culture

Sr. No	**Author (s)**	**Country**	**Study**	**Dimensions Mentioned**
1	Abas, et al. [1]	Malaysia	Safety	Safety inspection
2			performance	Safe System of Work
3			of construction	Safe plant and equipment
4			projects	Safe working environment
5				Safety officer and supervisor
6				Safety review for safety audit
7				Safety review for site safety policy review
8				Emergency plan and procedures
9				Hierarchical management and skilled labour
10				Reduced health and safety hazards
11	Demirkesen [21]	Turkey	Lean	Safety culture
12			implementation	Safety training
13			of safety	Safety leadership
14				Safety commitment
15				Safety incentives
16				Safety inspection and monitoring
17	Machfudiyanto, et al. [77]	Indonesia	Construction	Safety awareness
18			safety	Safe activities and conditions
19			culture	Safety concerns
20				Safety policy
21				Safety standards

2.7.1.1 Lean Leadership

Lean leadership pays close attention to the idea, process, people and partners, and issue solutions, which is crucial for long-term Lean adoption [78]. The following articles have addressed factors affecting leam leadership. Lean culture helps in improving the role of lean leadership. Therefore, the following hypotheses have been established.

Hypothesis 1: Lean culture is positively and significantly associated with lean leadership.

Hypothesis 2: The dimensions of lean culture are positively associated with lean leadership.

Table 2.2: Factors of Lean Leadership

Sr. No	Author (s)	Country	Study	Factors Mentioned
1	Valente, et al. [28]	USA	Lean implementation	Shareholders' commitment to lean construction principles
2	Bahnariu [79]	Romania	Factors for a	Rules and regulations
3			lean culture	People development based on lean thinking
4				The long-term interest of stakeholders
5				Decisions based on data and facts
6				Accepting foreign ideas
7				Service-based leadership/ leading with humility
8				Acting with a sense of urgency
9				Strong beliefs about right and good
10				Treating controlled failures as learning labs
11				Encouraging exposure to problems

Continued Table 2.2 Factors of Lean Leadership

Sr. No	**Author (s)**	**Country**	**Study**	**Factors Mentioned**
12	Kalyan, et al. [80]	India	Building a	Value orientation/ value specification
13			lean culture	Seeking perfection
14				Embracing scientific thinking
15				Systemically thinking
16				Constancy of purpose
17				Flow and pull value
18				Transformational leadership
19	Demirkesen [21]	Turkey	Lean	Motivation
20			implementation	Promotions
21			on safety	Reward systems
22				Bonus systems
23				Guiding principles
24				The leadership team (top management)
25				Encouraging employees to try new ideas
26				Praising employees
27				Leadership commitment
28	Demirkesen and Bayhan [26]	Turkey	The lean implementation	Willingness to invest in lean practices
29			success model	Strategic actions
30	Albalkhy and Sweis [27]	Jordan	Barriers to adopting	Strategies
31			lean construction	Lean training
32				Lean consultants

2.7.1.2 Teamwork

More people must collaborate with others in their work for the speed of change, fast schedules, and the variety of expertise required for most tasks. Lean culture enables the exposure of teamwork to a great extent [81]. Therefore, we establish the following hypotheses.

Hypothesis 3: Lean culture is positively and significantly associated with teamwork.

Hypothesis 4: The dimensions of lean culture are positively associated with teamwork.

Table 2.3: Factors of Teamwork

Sr.No	Author (s)	Country	Study	Factors Mentioned
1	Gomez, et al. [82]	USA	Lean and	Team support
2			psychological safety	The value generated for customers
3	Valente, et al. [28]	USA	Lean	Daily awareness of the surroundings
4			implementation	Commitment
5				Engagement
6				Shared meaningful goal
7				Bottom-up management
8	Demirkesen and Bayhan [26]	Turkey	Lean implementation	Employee morale
9			success model	A supportive environment for workforce efficiency
10				The existence of certified and qualified lean personnel
11				The efficiency of human resource management activities
12				Availability of consulting team members in lean

2.7.1.3 Management Role

The lean project manager's role is to educate all parties involved in construction on lean thinking, concepts, and practises, as well as to give advice and direction on how to optimise lean processes at a strategic level and across all projects [83]. Lean culture boosts a management role in the industry. Therefore, we establish the following hypotheses.

Hypothesis 5: Lean culture is positively and significantly associated with management role.

Hypothesis 6: The dimensions of lean culture are positively associated with management role.

Table 2.4: Factors of Management Role

Sr. No	Author (s)	Country	Study	Factors Mentioned
1	Valente, et al. [28]	USA	Lean	Encourage decisions
2			implementation	Concern and respect for employees
3				Safety and health preoccupation for workforce and labour
4				Benchmarking with academic researchers
5				Prototyping
6				Recognition and celebration of small and big victories
7				Autonomy being encouraged among employees
8				Allowing people to make mistakes and learn from them (learning and experimenting within the company)
9				Behaviour with employees
10	Gomez, et al. [82]	USA	Lean and psychological safety	Treating all people with dignity
11				Psychological safety

Continued Table 2.4 Factors of Management Role

Sr. No	Author (s)	Country	Study	Factors Mentioned
12	Bahnariu [79]	Romania	Factors for a lean culture	Lean principles
13	Demirkesen and Bayhan [26]	Turkey	Lean implementation success model	Management commitment
14	Aslam, et al. [84]	Pakistan	Factors for lean construction	Empowerment to employees for finding ways of doing things
15				Lean awareness to employees
16				Opportunities for employees to flourish
17	Demirkesen [21]	Turkey	Lean implementation on safety	Lean practices
18				Performance evaluations
19				Planning and staffing for safety
20				Lean tools

2.7.1.4 Social Responsibility

Government support, such as the establishment of regulations that allow for the use of Lean methods, is crucial to the success of lean practices and implementation [85]. Lean culture helps in improving social responsibility. Therefore, we establish the following hypotheses.

Table 2.5: Factors of Social Responsibility

Sr.No	Author (s)	Country	Study	Factors Mentioned
1	Valente, et al. [28]	USA	Lean implementation	Healthy habits
2	Demirkesen and Bayhan [26]	Turkey	Lean implementation success model	Supportive nature of governmental regulations in lean
3				Government incentives
4				Availability of resources for lean

Hypothesis 7: Lean culture is positively and significantly associated with social responsibility.

Hypothesis 8: The dimensions of lean culture are positively associated with social responsibility.

2.7.1.5 Working Environment

It is critical to have access to lean tools, methodologies, and software systems to create a lean-friendly atmosphere in construction projects [86, 87]. Lean culture helps in improving the working environment for staff and employees in the industry. Therefore, we establish the following hypotheses.

Hypothesis 9: Lean culture is positively and significantly associated with working environment.

Hypothesis 10: The dimensions of lean culture are positively associated with working environment.

Table 2.6: Factors of Working Environment

Sr.No	Author (s)	Country	Study	Factors Mentioned
1	Bahnariu [79]	Romania	Factors for a	Trust
2			lean culture	Values
3	Valente, et al. [28]	USA	Lean	Communication processes
4			implementation	Team spirit
5				Last planner system (LPS)
6				Elimination of fear
7	Gomez, et al. [82]	USA	Lean and psychological safety	Respect for people
9	Demirkesen [21]	Turkey	Lean implementation on safety	Worker behaviour
10				Lean thinking
11				Innovations in processes
12	Demirkesen and Bayhan [26]	Turkey	Lean	Lean tools and techniques

Continued Table 2.6 Factors of Working Environment

Sr.No	Author (s)	Country	Study	Factors Mentioned
13			implementation	A clear understanding of technical requirements in lean practices
14			success model	Morning huddles for lean
15				The effectiveness of value stream mapping
16				The existence of clear roles in lean
17				The existence of lean research groups and initiatives
18				The existence of communicating lean practices
19	Prayuda, et al. [88]	Indonesia	Development of	Just in time (JIT)
20			lean construction	Kaizen approach
21	Xing, et al. [83]	China	Implementation of lean	Constraint analysis
22			construction techniques	Concurrent engineering
23				Lean project delivery system (LPDS)
24				Target value delivery
25				Kanban system
26				5S method

2.7.1.6 Auditing and Continuous Improvement

Continuous improvement is done by embracing new challenges and expanding its horizons towards sustainability, digitalisation, and social responsibility [28]. Lean culture aids in auditing and continuous improvement of the industry professionals. Therefore, we establish the following hypotheses.

Hypothesis 11: Lean culture is positively and significantly associated with auditing and continuous improvement.

Hypothesis 12: The dimensions of lean culture are positively associated with auditing and continuous improvement.

Table 2.7: Factors of Auditing and Continuous Improvement

Sr. No	Author (s)	Country	Study	Factors Mentioned
1	Valente, et al. [28]	USA	Lean implementation	Continuous education
2	Albalkhy and Sweis [27]	Jordan	Barriers to adopting lean construction	Top-down management
3	Demirkesen and Bayhan [26]	Turkey	Lean implementation success model	Customer satisfaction
4	Bahnariu [79]	Romania	Factors for lean culture	Genchi Genbutsu (go and see)
5				Encouraging and helping employees
6				Standardised tasks and processes
7	Demirkesen [21]	Turkey	Lean implementation	Teamwork
8			on safety	Creative thinking
9				Problem-solving
10				Collaborative practices

2.8 Summary of Hypotheses

This section presents the number of hypotheses developed in the previous section 2.7. All the hypotheses are as below:

Hypothesis 1: Lean culture is positively and significantly associated with lean leadership.

Hypothesis 2: The dimensions of lean culture are positively associated with lean leadership.

Hypothesis 3: Lean culture is positively and significantly associated with teamwork.

Hypothesis 4: The dimensions of lean culture are positively associated with teamwork.

Hypothesis 5: Lean culture is positively and significantly associated with management role.

Hypothesis 6: The dimensions of lean culture are positively associated with management role.

Hypothesis 7: Lean culture is positively and significantly associated with social responsibility.

Hypothesis 8: The dimensions of lean culture are positively associated with social responsibility.

Hypothesis 9: Lean culture is positively and significantly associated with working environment.

Hypothesis 10: The dimensions of lean culture are positively associated with working environment.

Hypothesis 11: Lean culture is positively and significantly associated with auditing and continuous improvement.

Hypothesis 12: The dimensions of lean culture are positively associated with auditing and continuous improvement.

2.9 Methods to Address Health and Safety Issues

Kamal et al. [89] performed a risk evaluation analysis and identified risks from previous research and carried out a questionnaire survey to obtain the impact values of the identified health and safety risk factors. During risk assessment, Zhao and Guo [90] used a Fuzzy Evaluation method to measure the frequency and level of impact for all the risk factors. Yap and Lee [91] used the technique that consisted of risk factors and classified those risk factors by using a questionnaire survey. Nawaz et al. [92] used statistical package for social sciences (SPSS) to conduct data collection analysis for the questionnaire survey. Idrees [93] developed a health and safety framework using Analytic Hierarchy Process (AHP) for building construction projects in Pakistan.

Wali and Mahdi [94] developed a questionnaire to be answered on a 1-5 scale for assessing the impact value of the identified factors. The survey was carried out by using an ordinal scale and an analysis of all the risk factors was conducted to measure the impact on the work efficiency, cost and health and safety of the workers. The significance level and ranks of all the risk factors were determined by the relative importance index (RII) formula. Zahoor et al. [95] executed the questionnaire data to evaluate the impact value of all the risk factors using the RII formula. Raheem and Issa [11] pointed out the risk factors from the literature and doing a questionnaire survey, found out the risk impact values and ranked the factors based on calculated impact values. By using the average formula firstly, the total sum of all the factors was calculated and then percentage values were.

2.9.1 Multi-Criteria Decision-Making Techniques

Multi-criteria decision-making (MCDM) is an operational research analysis that is typically used to solve complex decision-making problems. It allows evaluation and multiple expert judgements and is used to resolve the existence of imprecision and ambiguous information in the evaluation process [96]. It requires more than one set of criteria for establishing qualitative judgement. MCDM method chooses and ranks the alternatives using numerous decision criteria [97]. It is interpreted as the procedure of identifying the supreme alternatives amid all the viable options. It is particularly the major branch of decision-making and is used to determine the right solution from the available alternatives [98]. The general flow chart of the MCDM technique follows eight steps for the decision-making process [93] as shown in **Figure 2.5**.

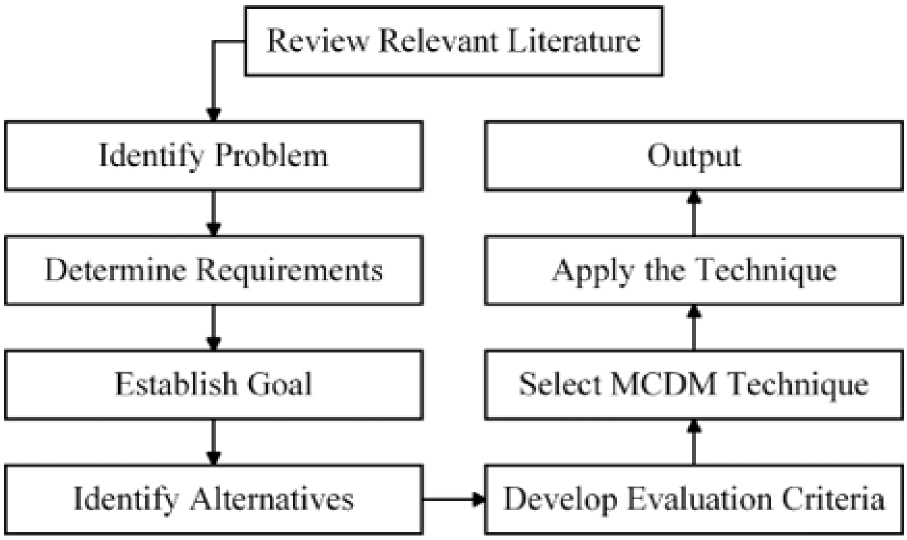


FIGURE 2.5: General Approach for MCDM Technique [93]

Fig 2.5 demonstrates that selecting the pertinent decision-making method is the first step in the decision-making process to accomplish the goal and objectives. In the second stage, criteria must be decided based on expert judgments. In the third step, the goal must be comprehensible and interpreted favourably. The fourth step is to identify alternatives. Alternatives are the strategies that turn the preliminary condition into a preferred condition. Stage five includes defining and evaluating the requirements in the decision-making process. In the sixth step, the decision method is chosen. There are many techniques in MCDM like analytic hierarchy process (AHP), analytical network process (ANP), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), data envelopment analysis (DEA), fuzzy decision making and structural equation modelling (SEM). SEM is a multivariate quantitative method for describing relationships between variables. The technique supports the researcher in testing or validating a theoretical model for theory testing and extension. The purpose of multivariate analysis is to help the researcher undertake an in-depth explanatory investigation with the necessary statistical efficiency [99-103].

2.9.2 Structural Equation Modelling

Structural equation modelling (SEM) is a multivariate quantitative technique employed to describe the relationships among observed variables. The technique helps the researcher to test or validate a theoretical model for theory testing and extension [104]. The multivariate analysis is conducted to help the researcher with in-depth explanatory analysis with the required statistical efficiency [105]. By validating scientific ideas and increasing the present body of knowledge by detecting intricate relationships between components, structural equation modelling (SEM) allows the researcher to perform a more in-depth inquiry [106]. Using different multivariate approaches, it is difficult to assess a researcher's complete hypothesis, SEM should be considered as an extension of current multivariate techniques such as factor analysis and multiple regression analysis [108]. SEM is regarded to be a particularly effective method for simultaneously examining many dependent variables by solving multiple equations [109]. An overview of the SEM process is presented in Figure 2.5. There are many powerful SEMs which are unexplored yet and are highly flexible. Some of the variants of SEMs are explained below [110].

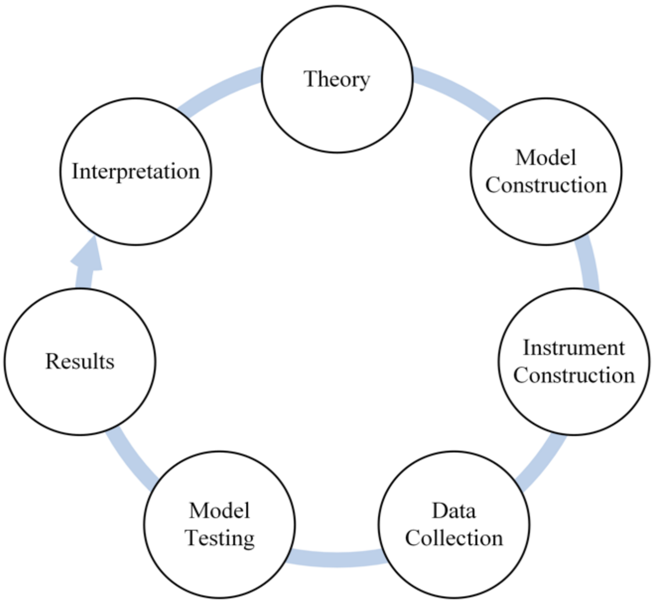


FIGURE 2.6: General Approach for Conducting SEM Analysis [110]

Table 2.8: History of Causality Models [110]

Year	Model	Key Contributors	Key Features
1896	Linear regression models	Karl Pearson	The regression weights are calculated based on the correlation coefficient and least squares criterion.
		(correlation coefficient)	It enables the prediction of dependent observed variable scores (Y) (e.g. sales of mobiles or no. of patients to be admitted, etc.)
1904-1927	Factor analysis	Charles Spearman	It determines which items correlated to create the factor model. It helps to define and measure a construct based on correlated items.
1940	Factor techniques	D. N. Lawley and L. L. Thurstone	Instruments (sets of items) that yield observed scores from which inferences about the constructs are made.
1955-1965	Confirmatory factor analysis (CFA)	Howe (1955),	Tests whether a set of items defined a construct.
		Anderson and Rubin (1956),	Used to create measurement instruments used in many academic disciplines.

Continued Table 2.8 History of Causality Models [110]

Year	Model	Key Contributors	Key Features
		and Lawley (1958) Karl Jöreskog (1960) Jöreskog (1963)	Used to test the existence of the theoretical constructs.
1918-1960	Path models	Sewell Wright (1918–1934)	The complex relationships among observed variables are investigated using correlation coefficients and regression analysis.
		H. World (1950s)	The relationship among the observed variables in the path model is established by solving a set of simultaneous regression
		D. Duncan and H. M. Blalock (1960s)	equations.
1973-1994	Structural equation modelling (SEM)	Karl Jöreskog (1973)	It combines both path models and confirmatory factor models to incorporate both latent and observed variables.
		Ward Keesling (1972),	Initially known as the JKW model, the development of LISREL software in 1973 gave it a unique identity like the linear structural
		and David Wiley (1973) Jöreskog and van Thillo (LISREL in 1973)	relations model (LISREL).

2.9.3 Research Gap

An ongoing discussion about safety has been observed with individual attempts to make the workplace free of any accident [111]. However, the lack of an overarching understanding remains in the minds of current researchers and practitioners. This situation may be attributed to several reasons such as the complex nature, its multiple features, several fields of knowledge influencing different approaches, etc. Regarding the lean construction perspective, the manufacturing sector has encouraged a view of construction practices from a different perspective, by observing and understanding the whole process across the supply chain. Thus, opportunities to improve the performance of the construction sector, such as waste reduction, have been identified as a means to deliver value more efficiently to customers [112]. In 1992, lean thinking rose from obscurity into the construction sector by Koskela [113-115] and the simultaneous work of Howell and Ballard [116-126].

One year later, the first annual meeting of the IGLC community was held and continues as a forum for debating and disseminating ideas. Since 1993, the IGLC forum has largely discussed the concept of lean through the consideration of complementary approaches. The literature reflects a deeper understanding of lean construction practice and has resulted in an evolution of the lean culture perspective from an objective view to a more subjective one. Since then, many articles have been written on lean culture regarding its adoption, framework etc. but its role in safety is still missing. It has not been explored yet. That's why this research focuses on the role of lean culture in health and safety management at construction sites.

2.10 Chapter Summary

This chapter presented a brief review of previous literature based on the theoretical framework under investigation and devised hypotheses for empirical testing. Overall, the multi-dimensional model of lean culture was selected to be tested based on its comprehensive nature and availability of measurement scale. This chapter presented a bibliometric network using VOS viewer that represented important keywords for lean culture and health safety management. Safety issues faced in the construction industry have been discussed and to encounter them the role of culture in resolving safety issues has been presented, followed by a discussion of the relationship between lean culture and construction safety. Dimensions of lean culture and variables for outcome variables (lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement) were outlined through a detailed literature review. On the grounds of the literature reviewed, hypotheses for this research investigation have been established for data collection and examination by using different statistical tests. Finally, different methodologies to address health and safety issues in past have been discussed, followed by a research gap.

Chapter 3

Research Methodology

3.1 Introduction

This study illustrates the methods for effectively conducting the research and it will help to accumulate accurate information regarding health and safety management at construction sites in Pakistan. The data included primary and secondary types which helped to understand the culture of management at the construction site. The primary data included a survey among different people who work on the construction site. A structural equation modelling tool was used for gathering and analysing the information authentically for the research.

3.2 Research Design

The theory for this thesis is based on a detailed literature review which describes the role of lean culture in health and safety management in the construction industry. Fig 3.1 details the methodology in a graphical format.

This study has carried out importance of the lean culture related to health and safety risk factors impacting construction projects. A literature review was undertaken to study the relevant areas of current research work and to identify the risk factors for health and safety. The survey methodology has been used to collect the information through questionnaires from the site managers, construction professionals and construction workers at the site.

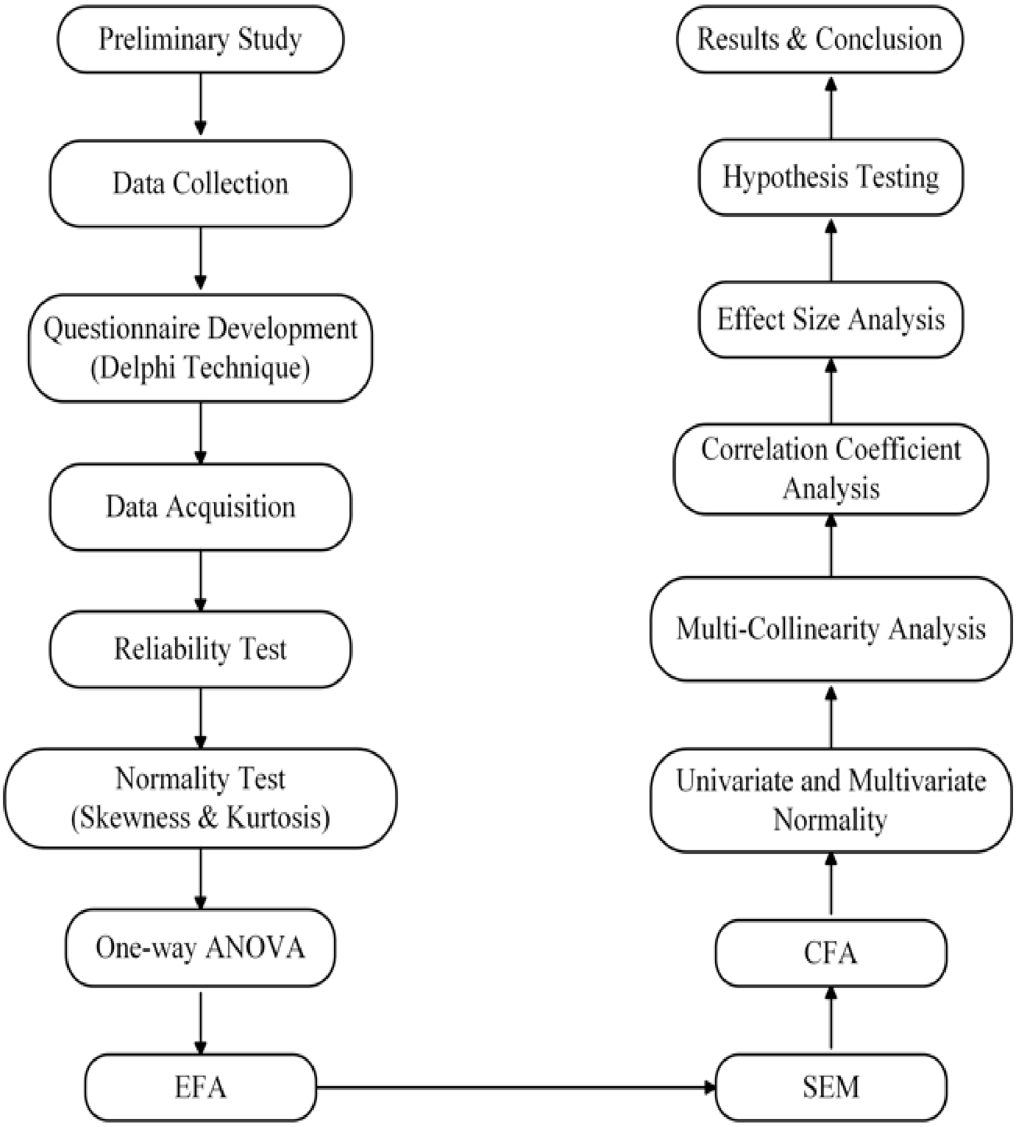


FIGURE 3.1: Flowchart for Research Design

This study was conducted with descriptive research that assisted in evaluating the lean culture implementations at construction sites in Pakistan. The Delphi method was used to shortlist the independent factors and to develop a questionnaire. A statistical method has been used to examine the information obtained.

To check the reliability and normality of data, reliability and normality test has been performed respectively using SPSS. In the case of normality, one-way ANOVA (Analysis of Variance) has been performed to analyse the impact of demographic variables on criterion variables using SPSS. Then, Exploratory Factor Analysis (EFA) has been carried out to compare the observed and identity matrix correlation of the dataset to ascertain any redundancy among the variable which can be summarized into factors. To accurately examine the hypothetical relationship between observed and latent variables, Confirmatory Factor Analysis (CFA) has been done. In structural equation modelling (SEM), first and second-order CFA analysis has been performed using Amos graphics. To check the normality of each variable and cumulative normality of all variables, univariate and multivariate normality test has been carried out. To validate whether there is any collinearity among the variables, multi-collinearity diagnostics have been performed. Then, correlation analysis guided how much the variables correlate with each other. Lastly, to measure the strength of the relationship between variables, effect size analysis has been carried out, followed by hypothesis testing. After the data analysis, results and conclusions are derived.

3.2.1 Preliminary Study

The research is based on the innovative role of the lean culture in the safety and health management of employees at the construction sites in Pakistan. The issues faced by the employees working at the construction site were focused on along with the detailed study of previous works of researchers. It has been learnt that role of lean culture provided a vital concern for safety management purposes in different construction sites. This research applied the SEM tools to measure the variables and understand the innovative role of the construction business.

This study also analyses the way it gathers information from the survey data and understands the health and safety management issues in the construction sites of Pakistan. The survey data was collected through an online process as well as physically from the employees who are working on the construction sites. The response helped to understand the lean culture and its problems. Besides that, it focuses on the specification model and the way the model helps to do the research more actively and appropriately.

3.2.2 Data Collection

Data collection is the stage in research in which appropriate and essential data are collected from the field in conjunction with the goals and aims of the study. Two key origins have been used for this research work, the first one is primary data, and the other is secondary data.

3.2.2.1 Primary Data

In this research, a survey was conducted to gather primary data regarding the research topic. The participants share their opinion regarding the health and safety issues of the construction worker at different sites. The participants were asked some demographic questions and some work-related questions to identify the issue in the lean culture and safety management of the construction site. This also included their educational qualification and professional experience in this field. This helped to understand their working experience and their qualification to do the work on construction sites. Besides that, feedback on identified factors and sub-factors was also acquired. The participants were also asked about the working environment and auditing and continuous improvement of the construction project and what kind of tools, technology, and software system are being used to improve the construction project in Pakistan.

3.2.2.2 Secondary Data

This study focuses on the innovative role of lean culture in the safety and health management of the construction sectors. Various researchers identified the factors related to lean culture and the way they influence safety management in the construction business. Proper identification of the health and safety from the secondary data helped to improve the working procedure of the construction sites in different ways. Besides that, it focuses on different strategies to develop the process of working in the construction business. The secondary data focuses on the issues which the construction sector is experiencing related to health and safety management to improve the success of the company. Besides that, it focuses on some strategies to maintain the safety of the people and guide them to take proper care while working on any construction sites. The main sources included previously published works, research articles, reports etc. The secondary data is collected from different online articles and journals, which provide information related to the research topic. The relevant resources also helped to understand the safety measures taken by the construction industry of Pakistan and the way it influences the process of working.

3.2.3 Questionnaire Development

Delphi method was performed in the development of a questionnaire survey for the acquisition of the data after literature review analysis, Fig. 3.2 [93]. Delphi method is a formal technique or process for communication, initially developed as a comprehensive prediction method based on a panel of professionals, researchers, and experts [127]. Delphi method and focus group conversations are typically implemented for feedback [128]. Usually, the nominal group technique and Delphi method are used for feedback but the Delphi technique offers conversations, and indirect communications along with a detectable written input that makes the procedure more extensive, simplified and effective than other techniques [129].

Several professionals in the industry were involved to give their beneficial feedback for the identification of important factors and development of the questionnaire, **Table 3.1**. Identified factors were short-listed based on the industry professional's collected feedback to be included in the questionnaire for further data gathering.

Table 3.1: Industry Professional's Background

Sr.No	**Designation**	**Experience**	**Category**	**Sector**
1	Chief Engineer	> 20 years	Client	Public
2	Project Director	> 20 years	Client	Public
3	Design Engineer	5-10 years	Consultant	Private
4	Project Manager	15-20 years	Contractor	Private
5	Construction Manager	10-15 years	Contractor	Private
6	Professor	15-20 years	Academia	Public/ Private
7	Associate/ Assistant Professor	10-15 years	Academia	Private/ Private

3.2.3.1 Pilot Study

Shortlisted factors have been listed after a detailed discussion with industry professionals, and experts and their feedback. These factors have been used to establish the questionnaire. Table 3.2 summarises the feedback.

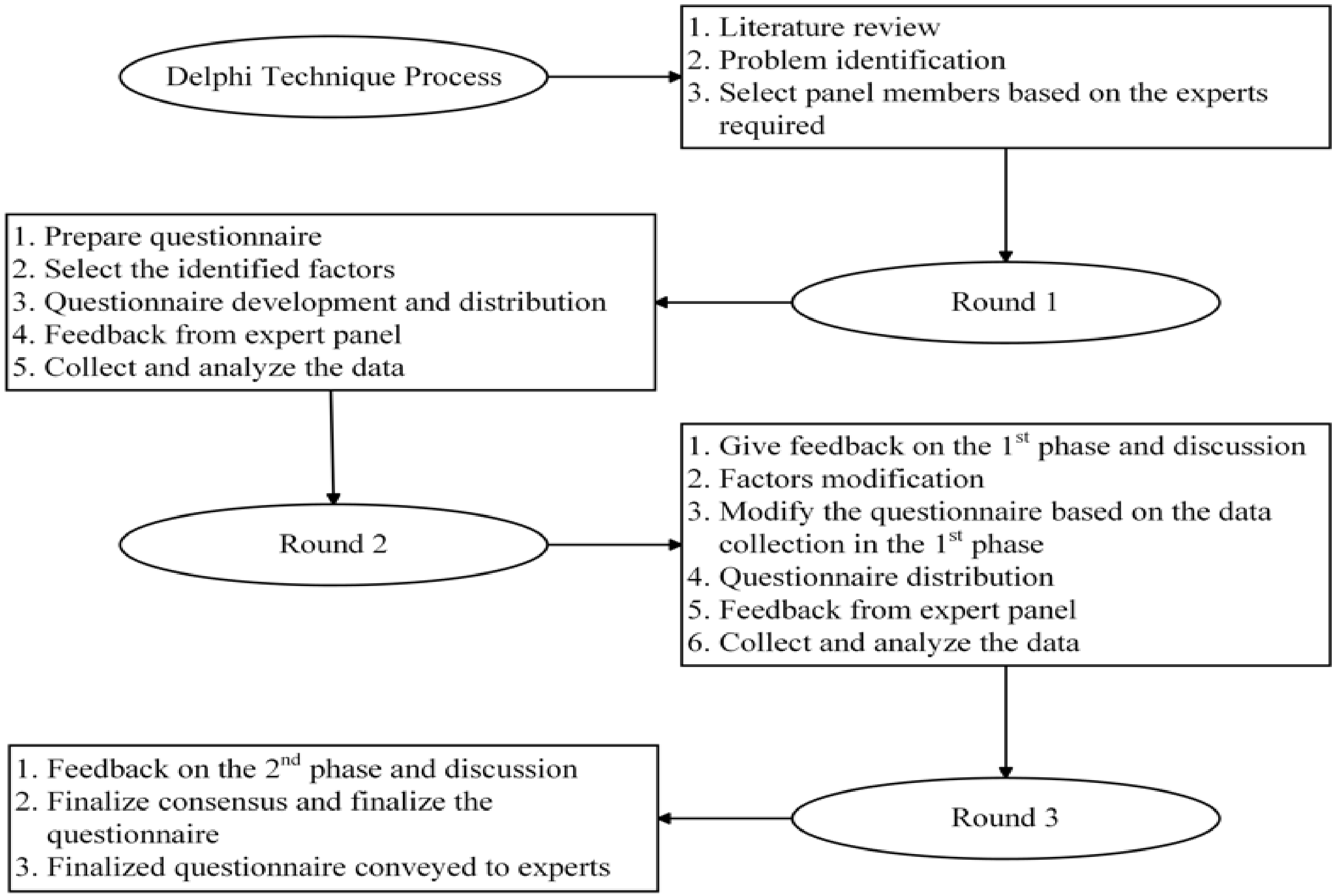


FIGURE 3.2: Delphi Technique Process [93]

Table 3.2: Identified Factors and their Inclusion Status

Sr. No	**Identified Factors**	**Inclusion Status**							
		1	2	3	4	5	6	7	**Total**
1	Safety Inspection	√		√		√			3
2	Safe System of Work	√			√		√		3
3	Safe Plant and Equipment		√		√				2
4	Safe Working Environment	√	√	√	√	√	√	√	7
5	Safety Officer and Supervisor	√		√	√	√	√	√	6
6	Safety Review for Safety Audit		√			√		√	3
7	Safety Review for Site Safety Policy Review			√			√		2
8	Emergency Plan and Procedures							√	1
9	Hierarchical Management and Skilled Labour		√				√		2
10	Reduced Health and Safety Hazards	√		√		√		√	4
11	Safety Culture		√		√			√	3
12	Safety Training	√	√		√	√		√	5
13	Safety Leadership			√			√		2
14	Safety Commitment		√	√		√	√		4
15	Safety Incentives	√		√	√			√	4
16	Safety Inspection and Monitoring	√	√	√	√		√	√	6
17	Safety Awareness	√	√	√	√	√	√	√	7
18	Safe activities and Conditions		√	√		√		√	4
19	Safety Concerns	√	√	√	√	√	√		6
20	Safety Policy		√	√	√	√	√	√	6
21	Safety Standards	√	√	√	√	√	√	√	7
22	Shareholders' Commitment to Lean Construction Principles	√	√		√	√		√	5
23	Rules and Regulations	√	√	√	√	√	√	√	7

Continued Table 3.2 Identified Factors and their Inclusion Status

Sr. No	**Identified Factors**	**Inclusion Status**							
		1	2	3	4	5	6	7	**Total**
24	People Development based on Lean Thinking		√	√		√	√		4
25	Long-term Interest of Stakeholders				√				1
26	Decisions based on Data and Facts	√		√	√	√	√	√	6
27	Accepting Foreign Ideas		√			√	√		3
28	Service-based Leadership/ Leading with Humility		√		√	√		√	4
29	Value Orientation/ Value Specification		√				√		2
30	Seeking Perfection			√					1
31	Embracing Scientific Thinking			√		√			2
32	Systemically Thinking				√				1
33	Constancy of Purpose	√	√	√		√	√	√	6
34	Flow and Pull Value							√	1
35	Transformational Leadership			√				√	2
36	Motivation	√	√		√	√	√		5
37	Promotions	√		√		√	√		4
38	Reward Systems		√	√	√	√	√	√	6
39	Bonus Systems	√			√			√	3
40	Guiding Principles	√	√	√		√	√	√	6
41	Leadership Team (Top Management)			√	√			√	3
42	Encouraging Employees to Try New Ideas		√	√	√		√		4
43	Praising Employees					√			1
44	Leadership Commitment					√	√		2

Continued Table 3.2 Identified Factors and their Inclusion Status

Sr. No	**Identified Factors**	**Inclusion Status**							
		1	2	3	4	5	6	7	**Total**
45	Willingness to invest in Lean Practices	√			√		√	√	4
46	Strategic Actions	√	√		√	√	√	√	6
47	Acting with a sense of urgency						√		1
48	Strong beliefs about right and good				√	√			2
49	Treating controlled failures as learning labs	√	√	√	√	√	√	√	7
50	Encouraging Exposure to Problems			√		√			2
51	Strategies	√							1
52	Lean Training		√		√		√		3
53	Lean Consultants			√		√		√	3
54	Team Support		√		√	√	√		4
55	Daily Awareness of the Surroundings			√		√			2
56	Commitment	√	√	√		√	√	√	6
57	Engagement	√			√		√	√	4
58	Shared Meaningful Goal		√	√		√	√		4
59	Employee Morale	√		√	√	√		√	5
60	Value Generated for Customers		√		√	√			3
61	Bottom-up Management							√	1
62	A Supportive Environment for Workforce Efficiency	√		√			√		3
63	The Existence of Certified and Qualified Lean Personnel	√				√		√	3
64	The Efficiency of Human Resource Management Activities			√			√		2
65	Availability of Consulting Team Members in Lean	√			√	√			3

Continued Table 3.2 Identified Factors and their Inclusion Status

Sr. No	**Identified Factors**	**Inclusion Status**							
		1	2	3	4	5	6	7	**Total**
66	Encourage Decisions	√	√		√	√		√	5
67	Concern and Respect for Employees	√		√	√	√	√	√	6
68	Safety and Health Preoccupation for Workforce and Labour		√	√	√		√	√	5
69	Benchmarking with academic researchers				√		√		2
70	Prototyping	√				√		√	3
71	Recognition and Celebration of Small and Big Victories	√	√		√			√	4
72	Autonomy being Encouraged among Employees		√			√	√		3
73	Allowing People to Make Mistakes and Learn from them		√	√		√		√	4
74	Behaviour with Employees			√		√	√		3
75	Treating all people with dignity	√		√	√	√	√	√	6
76	Psychological Safety					√		√	2
77	Lean Principles			√					1
78	Opportunities for Employees to Flourish	√				√	√	√	4
79	Empowerment to Employees for Finding Ways of Doing Things	√			√				2
80	Lean Awareness to Employees			√					1
81	Management Commitment	√	√		√	√		√	5
82	Lean Practices					√		√	2
83	Performance Evaluations	√	√	√	√	√	√	√	7
84	Planning and Staffing for Safety	√		√		√	√		4

Continued Table 3.2 Identified Factors and their Inclusion Status

Sr. No	**Identified Factors**	**Inclusion Status**							
		1	2	3	4	5	6	7	**Total**
85	Lean Tools	√			√		√		3
86	Healthy Habits		√	√			√	√	4
87	Supportive Nature of Governmental Regulations in Lean	√		√	√		√	√	5
88	Government Incentives			√	√	√	√		4
89	Availability of Resources for Lean	√	√	√	√	√	√	√	7
90	Trust			√	√		√	√	4
91	Communication Processes	√		√		√		√	4
92	Kaizen Approach	√							1
93	Team Spirit	√	√			√	√		4
94	Last Planner System				√				1
95	Elimination of Fear	√	√	√	√		√	√	6
96	Values			√	√	√			3
97	Respect for people			√	√	√		√	4
98	Worker Behaviour	√	√	√	√	√	√	√	7
99	Lean Thinking	√		√			√		3
100	Innovations in Processes		√	√		√		√	4
101	Lean Tools and Techniques				√	√			2
102	Morning Huddles for Lean	√			√				2
103	The Effectiveness of Value Stream Mapping	√	√						2
104	The Existence of Clear Roles in Lean		√	√		√	√	√	5

Continued Table 3.2 Identified Factors and their Inclusion Status

Sr. No	**Identified Factors**	**Inclusion Status**							
		1	2	3	4	5	6	7	**Total**
105	A Clear Understanding of Technical Requirements in Lean Practices	√		√		√	√	√	5
106	The Existence of Lean Research Groups and Initiatives	√		√		√	√		4
107	The Existence of Communicating Lean Practices	√		√					2
108	Just in Time (JIT)		√						1
109	Constraint Analysis				√				1
110	Concurrent Engineering					√			1
111	Lean Project Delivery System (LPDS)					√		√	2
112	Target Value Delivery	√	√		√	√	√	√	6
113	Kanban System	√		√					2
114	5S Method	√							1
115	Continuous Education		√	√		√		√	4
116	Genchi Genbutsu (Go and See)	√					√		2
117	Encouraging and Helping Employees		√		√		√	√	4
118	Standardised Task and Processes	√		√	√	√		√	5
119	Top-down Management		√		√	√		√	4
120	Teamwork	√	√	√	√	√	√	√	7
121	Creative Thinking	√	√		√	√	√		5
122	Problem Solving		√	√		√		√	4
123	Collaborative Practices	√		√	√	√	√	√	6
124	Customer Satisfaction		√	√	√		√	√	5

3.2.3.2 Likert Scale

The Likert scale has been adopted to analyse and understand the impact of different factors on understanding health and safety in construction sites [130]. The impact was measured by five measuring contexts; strongly disapprove, disapprove, undecided, approve and strongly approve; **Table 3.3**.

TABLE 3.3: Feedback Scale [130]

Sr. No.	Description	Score Range
1	Strongly Disapprove	1
2	Disapprove	2
3	Undecided	3
4	Approve	4
5	Strongly Approve	5

3.2.3.3 Coding Table

A total of 124 variables were identified from the literature review. After a detailed discussion with experts and their feedback, only those factors were shortlisted which achieved 50% consideration. Thus, 65 factors matched the criteria of selection for the questionnaire. These short-listed factors have been divided into 7 groups (named latent variables) and these 65 factors have been regarded as measured variables to be used in SEM analysis.

Factors of Lean Culture in Safety;

A total of 21 dimensions of lean culture were collected from the literature review. Out of 21 dimensions, just 12 dimensions were short-listed after feedback. These short-listed dimensions have been used in SEM analysis and their codes are given in **Table 3.4**.

Table 3.4: Short-Listed Dimensions Of Lean Culture

Sr. No	**Measured Variables**	**Codes**
1	Safe Working Environment	LC1
2	Safety Officer and Supervisor	LC2
3	Reduced Health and Safety Hazards	LC3
4	Safety Training	LC4
5	Safety Commitment	LC5
6	Safety Incentives	LC6
7	Safety Inspection and Monitoring	LC7
8	Safety Awareness	LC8
9	Safe activities and Conditions	LC9
10	Safety Concerns	LC10
11	Safety Policy	LC11
12	Safety Standards	LC12

Out of short-listed 65 factors, 12 are dimensions of lean culture while the remaining 53 variables have been divided into these 6 groups to be used as dependent variables in SEM analysis. **Table 3.5** summarizes the details of these six (06) groups.

Table 3.5: Dependent Variables

Sr. No	**Dependent Variables**	**Codes**
1	Lean Leadership	LL
2	Teamwork	TW
3	Management Role	MR
4	Social Responsibility	SR
5	Working Environment	WE
6	Auditing and Continuous Improvement	AC

Lean Leadership;

A total of 32 measured variables of lean leadership were identified. Out of 32 factors, just 14 were short-listed after feedback. These short-listed variables used in SEM analysis are detailed in **Table 3.6**.

Table 3.6: Short-Listed Factors of Lean Leadership

Sr. No	**Measured Variables**	**Codes**
1	Applying Lean Construction Principles	LL1
2	Rules and Regulations	LL2
3	People Development based on Lean Thinking	LL3
4	Decisions based on Data and Facts	LL4
5	Leading with Humility	LL5
6	Consistency of Purpose	LL6
7	Motivation	LL7
8	Promotions	LL8
9	Reward Systems	LL9
10	Guiding Principles	LL10
11	Encouraging Employees to Try Ideas	LL11
12	Willingness to invest in Lean practices	LL12
13	Strategic Actions	LL13
14	Treating controlled failures as learning labs	LL14

Teamwork;

A total of 12 measured variables of teamwork were identified. Out of 12 factors, just 5 were short-listed after feedback. These short-listed variables used in SEM analysis are detailed in **Table 3.7**.

Table 3.7: Short-Listed Factors of Teamwork

Sr. No	**Measured Variables**	**Codes**
1	Team Support	TW1
2	Commitment	TW2
3	Engagement	TW3
4	Shared Meaningful Goal	TW4
5	Employee Morale	TW5

Management Role;

A total of 20 measured variables of management role were identified. Out of 20 factors, just 10 were short-listed after feedback. These short-listed variables used in SEM analysis are detailed in **Table 3.8**.

Table 3.8: Short-Listed Factors Of Management Role

Sr. No	Measured Variables	Codes
1	Encourage Decisions	MR1
2	Concern and Respect for Employees	MR2
3	Safety and Health Preoccupation with workforce and labour	MR3
4	Recognition and Celebration of Small and Big Victories	MR4
5	Learn from mistakes	MR5
6	Treating all people with dignity	MR6
7	Opportunities to Employees to Flourish	MR7
8	Management Commitment	MR8
9	Performance Evaluations	MR9
10	Planning and Staffing for Safety	MR10

Social Responsibility;

A total of 4 measured variables of social responsibility were included. All are selected after feedback. These variables used in SEM analysis are detailed in **Table 3.9.**

Table 3.9: Short-Listed Factors of Social Responsibility

Sr. No	Measured Variables	Codes
1	Healthy Habits	SR1
2	Supportive Nature of Governmental Regulations in Lean	SR2
3	Government Incentives	SR3
4	Availability of Resources for Lean	SR4

Working Environment;

A total of 25 measured variables of working environment were included. Out of 25 factors, just 11 were short-listed after feedback. These short-listed variables used in SEM analysis are detailed in **Table 3.10**.

Table 3.10: Short-Listed Factors of Working Environment

Sr. No	Measured Variables	Codes
1	Trust	WE1
2	Communication Processes	WE2
3	Team Spirit	WE3
4	Elimination of Fear	WE4
5	Respect for People	WE5
6	Worker Behaviour	WE6
7	Innovations in Processes	WE7
8	A Clear Understanding of Technical Requirements in Lean Practices	WE8
9	The Existence of Clear Roles in Lean	WE9
10	The Existence of Lean Research Groups and Initiatives	WE10
11	Target Value Delivery	WE11

Auditing and Continuous Improvement;

A total of 10 measured variables of auditing and continuous improvement were identified. Out of 10 factors, 9 were short-listed after feedback. The factor "Genchi Genbutsu (Go and See)" was not selected because it got 2 recommendations ($<$ 50%) from a panel of 7 experts during the scrutiny of variables. These short-listed variables used in SEM analysis are detailed in **Table 3.11**.

Table 3.11: Short-Listed Factors of Auditing and Continuous Improvement

Sr. No	**Measured Variables**	**Codes**
1	Continuous Education	AC1
2	Encouraging and Helping Employees	AC2
3	Standardised Task and Processes	AC3
4	Top-down Management	AC4
5	Teamwork	AC5
6	Creative Thinking	AC6
7	Problem Solving	AC7
8	Collaborative Practices	AC8
9	Customer Satisfaction	AC9

3.2.4 Questionnaire Distribution

Considering difficulties arising due to Covid-19 as well as limited time and budget, a convenience sample was a viable option as it is much simple, prompt, and economical. The questionnaire was developed using Google Forms. Construction employees, local contractors, consultants, construction managers, site engineers, design engineers, planning engineers and safety supervisors were contacted by using email and social mediums such as WhatsApp etc. A total of 550 questionnaires were distributed and 462 were received back with a response rate of 84%. Out of 462 respondents, percentage of contractors, consultants, construction managers, site engineers, design engineers, planning engineers and safety supervisors was 15.8%, 13.42%, 9.1%, 16.45%, 14.72%, 11.03% and 19.48%, respectively.

3.2.5 Lean Culture Hierarchical Framework (LCHF)

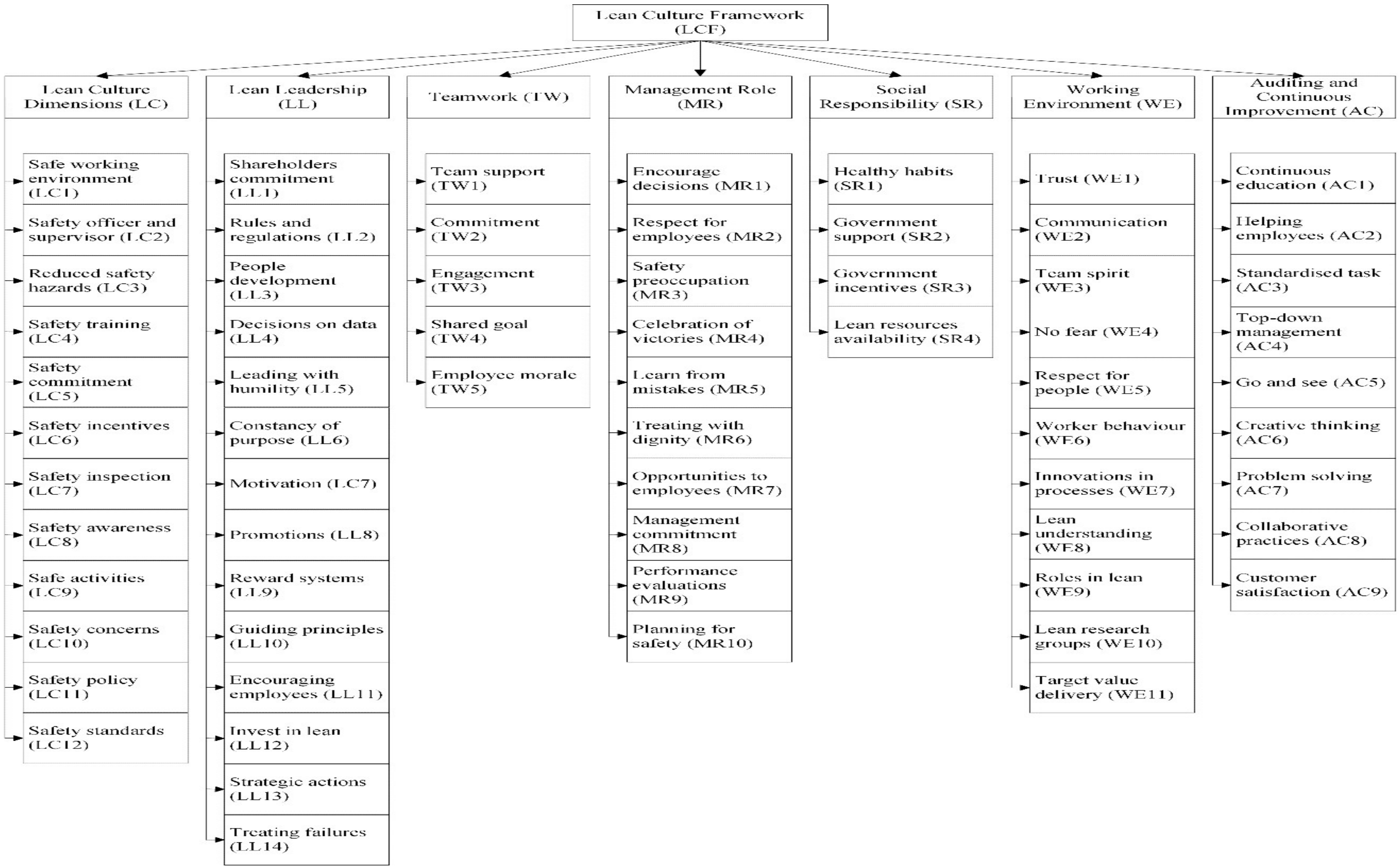


FIGURE 3.3: Lean Culture Hierarchical Framework

Figure 3.3 shows the hierarchical structure of all variables of lean culture. Dimensions and latent variables for lean culture have been summarised with their codes for ease in analysis. Lean culture has 12 dimensions from LC1 to LC12. Similarly, outcome variables, i.e., lean leadership, teamwork, management role, social responsibility, working environment, and auditing and continuous improvement have 14, 5, 10, 4, 11 and 9 observed variables through LL1 to LL14, TW1 to TW5, MR1 to MR10, SR1 to SR4, WE1 to WE11 and AC1 to AC9 respectively.

3.2.6 Data Analysis Tool

SPSS means "Statistical Package for the Social Sciences" which was introduced in 1968. SPSS is a commonly used application for mathematical research of social sciences. This mathematical tool is very easy to use, and accessible and numerous arithmetical experiments could be performed with this tool [131]. This mathematical tool tackles both comparative and correlational arithmetical experiments for both the parametric and non-parametric procedures [132]. The SPSS can gather statistics from a record and then use it to produce reports, graphs, charts, descriptive figures, and complicated arithmetical analysis [133]. SPSS can interpret the data and understand the data in depth and resolve complicated problems in research. With updated statistical methods, SPSS can easily comprehend substantial and complicated data sets [134]. For further analysis, Amos graphics has also been used which is a powerful structural equation modelling (SEM) software helping in research and theories by extending standard multivariate analysis methods, including regression, factor analysis, correlation and analysis of variance [135]. It builds attitudinal and behavioural models reflecting complex relationships more accurately than with standard multivariate statistics techniques using either an intuitive graphical or programmatic user interface [136].

3.3 Data Analysis

Collected data were analysed using statistical package for social sciences (SPSS) after collecting the data from the construction industry's professionals. Further analysis was done using Amos graphics. The collected data were examined as detailed below.

3.3.1 Reliability Analysis

The reliability test is one of the fundamental tests conducted to verify the reliability of the results. The test ensures that the statistics are stable and accurate [137]. Cronbach's alpha is a valuable analysis which is used to assess the reliability and the internal accuracy of any data collection. Its value above 0.7 is deemed appropriate and acceptable and ensures that data collected can be accurately evaluated for further study. Cronbach's alpha data sets are normally used in statistical studies as seen in table 3.12 [138].

Table 3.12: Internal Consistency and Cronbach's Alpha Values [1398]

Internal Consistency	**Cronbach's Alpha**
Excellent	$\alpha \geq 0.9$
Good	$0.9 > \alpha \geq 0.8$
Acceptable	$0.8 > \alpha \geq 0.7$
Questionable	$0.7 > \alpha \geq 0.6$
Poor	$0.6 > \alpha \geq 0.5$
Unacceptable	$\alpha < 0.5$

3.3.2 Normal Data Distribution Test

Although many statistical methods have been proposed to test the normality of data in various ways, there is no current gold standard method [139-141]. The formal normality tests including the Shapiro-Wilk test and Kolmogorov-Smirnov test may be used from small to medium-sized samples (e.g., $n < 300$), but may be unreliable for large samples. Another method of assessing the normality using skewness and kurtosis of the distribution may be used, which is relatively correct in both small samples and large samples [142].

3.3.2.1 Skewness and Kurtosis

Skewness is a measure of the asymmetry of the distribution of a variable. The skew value of a normal distribution is zero, usually implying symmetric distribution. A positive skew value indicates that the tail on the right side of the distribution is longer than the left side and the bulk of the values lie to the left of the mean. In contrast, a negative skew value indicates that the tail on the left side of the distribution is longer than the right side and the bulk of the values lie to the right of the mean [143]. It has been proposed as a reference of substantial departure from normality as an absolute skew value > 2. Kurtosis is a measure of the peakedness of a distribution.

The original kurtosis value is sometimes called kurtosis (proper) and it has been proposed as a reference of substantial departure from normality as an absolute kurtosis (proper) value > 7. For some practical reasons, most statistical packages such as SPSS provide 'excess' kurtosis obtained by subtracting 3 from the kurtosis (proper).

The excess kurtosis should be zero for a perfectly normal distribution. Distributions with positive excess kurtosis are called leptokurtic distribution meaning high peak, and distributions with negative excess kurtosis are called platykurtic distribution meaning flat-topped curve [144]. A z-test is applied for the normality test using skewness and kurtosis. A z-score could be obtained by dividing the skew values or excess kurtosis by their standard errors.

$Z = \frac{Skewvalue}{SE_skewness}$, $Z = \frac{ExcessKurtosis}{SE_excesskurtosis}$,

As the standard errors get smaller when the sample size increases, z-tests under the null hypothesis of normal distribution tend to be easily rejected in large samples with distribution which may not substantially differ from normality, while in small samples null hypothesis of normality tends to be more easily accepted than necessary. Therefore, critical values for rejecting the null hypotheses need to be different according to the sample size as follows. For small samples (n $<$ 50), if absolute z-scores for either skewness or kurtosis are larger than 1.96, which corresponds with an alpha level of 0.05, then reject the null hypothesis and conclude the distribution of the sample is non-normal. For medium-sized samples ($50 < n < 300$), reject the null hypothesis at an absolute z-value over 3.29, which corresponds with an alpha level of 0.05, and conclude the distribution of the sample is non-normal. For sample sizes greater than 300, it depends on the histograms and the absolute values of skewness and kurtosis without considering z-values. Either an absolute skew value larger than 2 or an absolute kurtosis (proper) larger than 7 may be used as reference values for determining substantial non-normality [145].

3.3.3 One-way ANOVA Test

One-way ANOVA is preferred for parametric data while the Kruskal Wallis test is suggested for non-parametric data analysis for better results [146]. The One-Way ANOVA method uses a single component (independent) variable to do a one-way analysis of variance for a quantitative dependent variable. The analysis of variance is used to test the assumption that all means are equal. The two-sample t-test is extended in this manner. The null and alternative hypotheses of one-way ANOVA are expressed as:

Null hypothesis (H_0): $\mu_1 = \mu_2 = \mu_3; = \mu_k$ (all k population means are equal)

Alternative hypothesis (H_1): At least one μ_i is different (at least one of the k population means is not equal to the others)

Where, μ_i is the population mean of the i^{th} group (i = 1, 2, 3, ..., k) [147]

3.3.4 Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) is a data reduction technique which is used to produce a meaningful set of information. It uses different techniques to determine the factor structure of the collected data [148]. One of them is Kaiser-Meyer-Olkin (KMO), a measure of sampling adequacy test, used to determine the significance of factor analysis. This test ensures the adequacy of the dataset by indicating a proportion of variance in the sample due to underlying factors. KMO test can assume a value spanning from 0 to 1, generally higher values, i.e., close to 1, and indicates that factor analysis may bring useful outcomes and a greater fit of the model [149]. Different KMO values indicate a different degree of sampling adequacy. Cerny and Kaiser [149] have established standard criteria for KMO estimates; for example, any KMO value above .9 to 1 is marvellous, any KMO value above .8 to .89 is meritorious, any KMO value above .7 to .79 is middling, any KMO value above .6 to .69 is mediocre, any KMO value above .5 to .59 is miserable and any value below .5 (i.e., 0 to .49) is poor and not acceptable. The minimum acceptable value for KMO is above 0.60 and any value below this is not acceptable. A summary of this standard criterion is presented in **Table 3.13.**.

TABLE 3.13: Criteria for KMO Estimate [149]

Sampling Adequacy	**KMO Value**
Marvellous	0.9 - 1
Meritorious	0.8 - 0.89
Middling	0.7 - 0.79
Mediocre	0.6 - 0.69
Miserable	0.5 - 0.50
Unacceptable	0 - 0.49

3.3.5 Structural Equation Modelling (SEM)

SEM measurement models contain evaluations of external measurement error components, as well as their hypothesised latent variable. Furthermore, the structural model is concerned with the modelling of latent variable relationships. This technique analyses the extent to which changes in one variable are linked to changes in one or more variables using the association coefficient. Because it enables the simultaneous assessment of several variables and their interrelationships, SEM is frequently employed. Apart from that, it is further adaptable compared to other multivariate methods because it allows for simultaneous, multiple dependent relationships among variables [110]. As a consequence, the research model was evaluated using SEM, and the analyses were carried out using AMOS 23.0. As a consequence, SEM was utilised to evaluate the rationality of each latent variable's observable variables using the proposed model. After then, the proposed model was adjusted to improve its goodness of fit. Figure 3.4 depicts a flowchart of the five stages involved in SEM analysis.

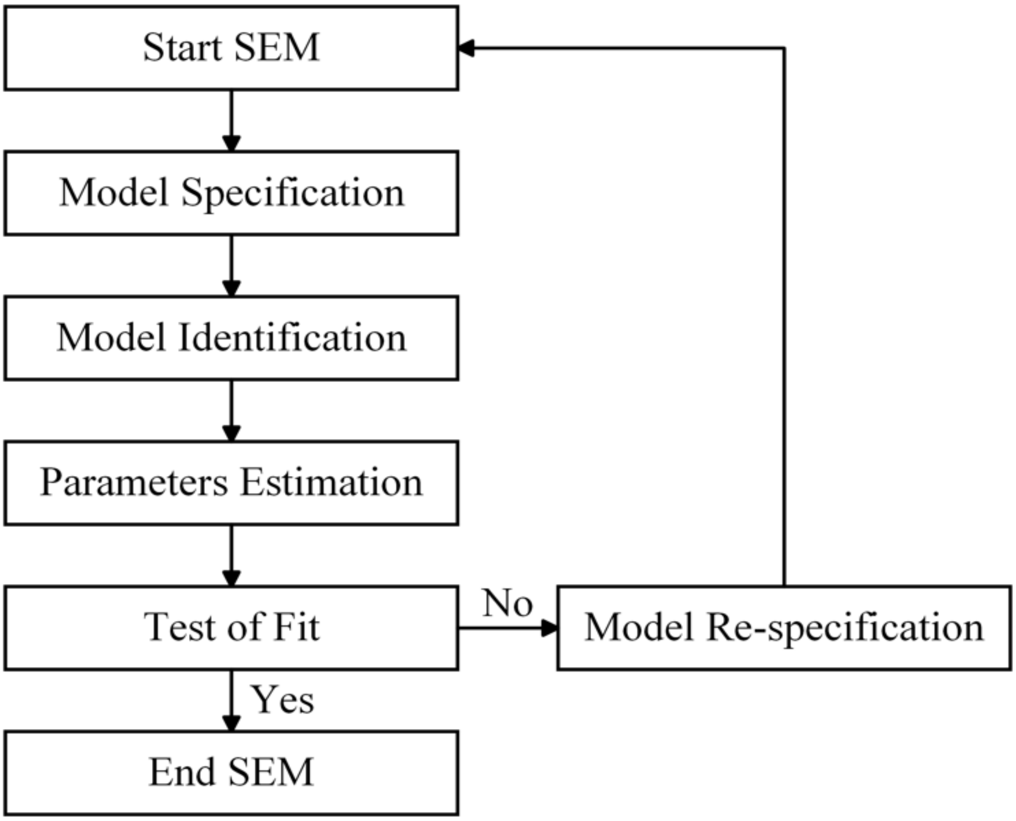


FIGURE 3.4: SEM Analysis Flowchart [110]

3.3.5.1 Model Specification

In SEM analysis, the model formulation is the first step. It takes place before data collection and data modelling. This requires developing a theoretical model based on existing literature and theory to characterise the variables and their interactions. Because this is a difficult endeavour, it is suggested that the model be based on existing research and evolved from there.

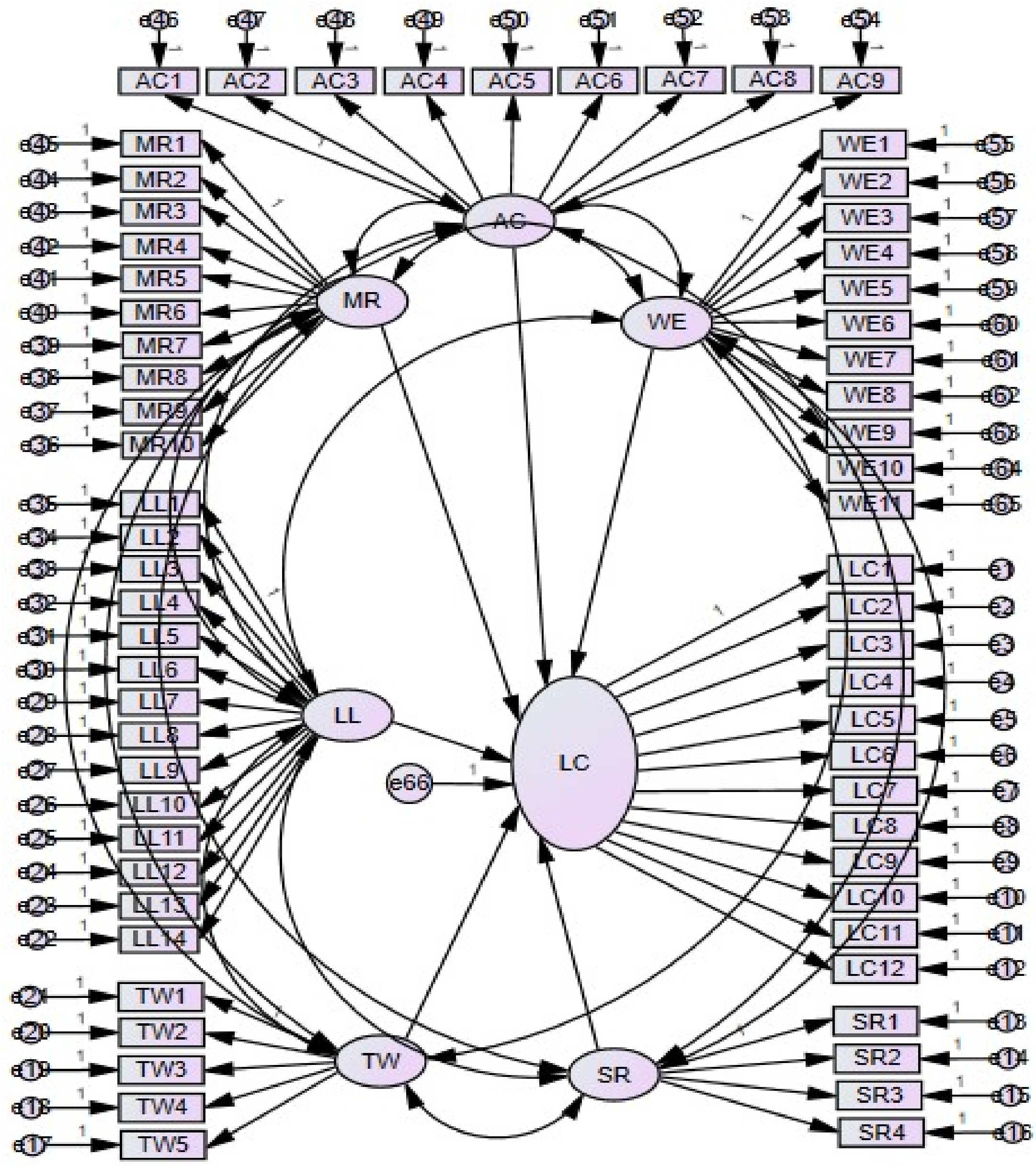


Figure 3.5: Model Specification

The hypotheses developed based on the literature are mentioned below. **Hypothesis 1:** Lean culture is positively and significantly associated with lean leadership.

Hypothesis 2: The dimensions of lean culture are positively associated with lean leadership.

Hypothesis 3: Lean culture is positively and significantly associated with teamwork.

Hypothesis 4: The dimensions of lean culture are positively associated with teamwork.

Hypothesis 5: Lean culture is positively and significantly associated with management role.

Hypothesis 6: The dimensions of lean culture are positively associated with management role.

Hypothesis 7: Lean culture is positively and significantly associated with social responsibility.

Hypothesis 8: The dimensions of lean culture are positively associated with social responsibility.

Hypothesis 9: Lean culture is positively and significantly associated with working environment.

Hypothesis 10: The dimensions of lean culture are positively associated with working environment.

Hypothesis 11: Lean culture is positively and significantly associated with auditing and continuous improvement.

Hypothesis 12: The dimensions of lean culture are positively associated with auditing and continuous improvement.

The model must be well-defined, and it must explain both the model's relationships and the logic behind it [150]. The first step is to create a measuring model that includes all latent characteristics. The structural model is specified when the latent construct in the measurement model is aptly measured by the observed variable as the measurement model does not specify the directional relationship between the latent variables [151]. The structural model, in its theoretical form, establishes the relationship between latent variables. It should go without saying that such a link should be indicated before model estimation and testing [152].

The derived structural equation evaluates the structure coefficient in question. The degree of variation in the latent endogenous variables is specified by the prediction error in each equation. The equation also includes the predicted connections [153].

These connections between latent and observable variables are also illustrated in Fig. 3.5's route diagram.

In Fig. 3.5, LC, LL, TW, MR, SR, WE and AC are latent/dependent variables. LL1 to LL14, TW1 to TW5, MR1 to MR10, SR1 to SR4, WE1 to WE11, AC1 to AC9 and LC1 to LC12 are measured/ observed variables. The e1 to e66 are error/unique variables. LL, TW, MR, SR, WE and AC are linked with each other through covariances. There are 6 dependent variables, 1 latent variable, 65 measured variables, 66 error variances, 64 factor loadings, 6 factor variances and 15 covariances.

3.3.5.2 Model Identification

SEM methodology has been adopted to improve the stability and reliability of the model [154]. Besides that, model identification checks the model and its working procedure to improve the quality of the research. It helps to understand the theoretical aspects of the research and learn the true values of the research factors by the researcher in an authentic way. However, there are major assumptions that the structural modelling has used, such as no systematic missing data, multivariate normality, and correct model specification [155].

Model identification is done by calculating the degree of freedom (df).

Degree of freedom (df) = Known Parameters – Unknown Parameters

Known and unknown parameters can be calculated from the following equation [156].

Known Parameters = $\frac{1}{2}$(S=1 $\times S$)

Unknown Parameters = Error variances + factor loadings + factor variances + covariances between latent variables / path coefficients

Where; S is a number of measured variables. The model developed in this research has

Measured variables = S = 65

So, Known Parameters = $\frac{1}{2}$ (S+1) × S = $\frac{1}{2}$ (65+1) × 65 = 2145

There are 66 error variances, 64 factor loadings, 6 factor variances and 15 covariances between latent variables in the model used in this research.

So, Unknown parameters = 66 + 64 + 6 + 15 = 151

Thus,

Degree of freedom (df) = Known Parameters – Unknown Parameters = 2145 – 151 = 1994.

Model coefficients can only be estimated in just-identified or over-identified models. Therefore, most researchers prefer to work with an over-identified model for model fitting and further analysis. The model is over-identified, just identified, and under-identified if df is positive, zero and negative respectively [157]. The degree of freedom (df) for the model used in this study is positive (1994), the model is over-identified so model fitting and further analysis can be done for this model.

3.3.5.3 Parameters Estimation

The third part of the investigation is a model estimation. The theoretical model parameters are estimated in such a way that the theoretical parameter values create a covariance matrix that is comparable to the observed covariance matrix S [158]. The fitting function is an iterative aspect of SEM. The fitting function is used in each iterative computing cycle to minimise the difference between the observed covariance matrix S and the calculated theoretical covariance matrix P, hence increasing the major parameter estimations [159].

In the final estimations, the best fit parameter to the observed covariance matrix S is supplied. Least squares, maximum likelihood (ML), asymptotic distribution free (ADF), unweighted least squares (ULS), and generalised least squares (GLS) are some of the estimation methods available [160]. The most common estimation method is the maximum likelihood (ML), followed by generalised least squares (GLS). Although ML and GLS are similar to ordinary least squares (OLS) estimation, they provide several advantages. In large samples, ML and GLS, in particular, are (a) not scale-dependent, (b) accept dichotomous exogenous variables, and (c) produce consistent and asymptotically efficient results.

Because they estimate all model parameters simultaneously to generate a comprehensive estimation model while assuming multivariate normality of dependent variables, ML and GLS are full information techniques [161]. OLS has a serious flaw in this area. When multivariate normality is violated, using an asymptotically distribution-free (ADF) estimator is recommended. Although ADF does not rely on the data's underlying distribution, it does require a large sample size because the estimator provides incorrect chi-square (χ^2) statistics with smaller sample sizes [162, 163].

3.3.5.4 Test of Fit

The test helps to understand the sample data, develop statistical hypotheses of the survey and to improve the quality of the research. The goodness of fit helps to understand the actual values of the research and properly observe the value [159].

Model testing requires looking at two conceptually distinct models: structural and measurement models. It's crucial to make sure the observed variable chosen for the latent variable is a good representation of the construct. In the absence of such verification, the structural model is rendered useless [164]. Model fitting is complicated by the fact that power varies with sample size [159].

The single path coefficient, such as p-value and standard error, and the entire model, such as ξ^2, and RMSEA, are frequently examined using fit indices in SEM [165]. Absolute fit indices, relative (incremental) fit indices, and parsimony fit indices are the three types of model-of-fit indices, and their values are listed in **Table 3.14** [111].

It's tough to give a fundamental fitness indices guideline that can help researchers discriminate between good and bad models. On the other side, the chosen recommendations are outlined. The goodness of the model should be verified using three to four indices of different types. Index cut-off values should be adjusted based on model characteristics [166].

Table 3.14: Model-fit indices [111]

Model-of-fit indices	**Full name/ key concerns**	**Cut-off value**
Absolute fit indices		
Model chi-square (χ^2)	Chi-square (use only for sample n $<$ 200 or p $>$ 0.05)	Insignificant result (p $>$ 0.05)
χ^2/df	Relative/normed chi-square (use only for sample n $>$ 200 or if p $<$ 0.05)	$<$2.0
RMSEA	Root mean square error of approximation	Value between 0.08 and 0.10 (mediocre fit), $<$ 0.08 (good fit)
GFI	Goodness of fit index Exhibits bias towards samples	Value $>$0.90 or $>$0.95 (use 0.95 if factor loading and number of samples are low)
AGFI	Adjusted goodness of fit index	$>$0.80
	Needs to be accompanied by other indices	
RMR	Root mean square residual	N/A

Continued Table 3.14 Model-fit Indices [111]

Model-of-fit indices	**Full name/ key concerns**	**Cut-off value**
SRMR	Standardized root mean square residual	<0.05
Relative (Incremental) fit indices		
NFI	Normed fit index	>0.90
	Sensitive to sample size < 200 Must be accompanied by other indices	
NNFI (also called TLI)	Non-normed fit index (Tucker Lewis Index)	>0.80
CFI	Comparative fit index	≥ 0.90
	A revised version of NFI	
	Less affected by sample size	
Parsimony fit indices		
PGFI	Parsimony goodness of fit index	>0.90
PNFI	Parsimonious normed fit index	>0.90

3.3.5.5 Re-Specification

This is the final step of structural equation modelling, also known as a model modification. Sometimes, it is required to modify the model so that the best-fitted model can be explored which fits the data perfectly. The model's standardised residual matrix, also known as fitted residuals, must be reviewed after a model specification search, which eliminates non-significant parameters from the theoretical model (also known as theory trimming) [167]. Because large values in the matrix signify misspecification of the overall model, while large values across an individual variable imply misspecification in that variable only, all values of modest magnitude should be detected while evaluating the standardised residual matrix [168].

3.3.6 Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis (CFA) is a statistical approach used to verify the factor structure of the dataset which is composed of observed variables. CFA helps in the better conceptualization of observed variables and their interpretation. Further, CFA analysis enables to accurately examine the hypothetical relationship between observed and latent variables [151]. Primarily, lean culture was considered as a unidimensional construct followed by the identification of various dimensions of lean culture. The second-order CFA was conducted by connecting all the indicators to their respective latent variable. A consolidated CFA was examined to observe a composite measurement model including all independent and dependent variables. To achieve a superior fitting model, post hoc adjustments were made to the consolidated CFA model, by correlating some error variables of dependent variables with each other, resulting in a good fit model.

3.3.7 Univariate and Multivariate Normality

In the complete measurement model, there are a total of 65 independent variables and the normality of each variable is called univariate normality, while the normality of the whole model is known as multivariate normality [169, 170]. In

SEM, univariate normality is not very important but multivariate normality because maximum likelihood (ML) has been chosen for the estimation and in ML estimation, multivariate normality matters [171]. These normality values include Skewness value, kurtosis value, critical ratio (c.r) value of skewness and kurtosis, multivariate kurtosis value and multivariate c.r value. Byrne [172] suggested that skewness values greater than 3 (in absolute value) may be considered indicative of more extreme levels of skew. She adopted a kurtosis value of >7 indicating a more substantial departure from normality. She suggested that kurtosis values ranging from 8 - 20 may be taken as indicating more "extreme" levels of kurtosis. She suggests that kurtosis is more relevant than skewness in the context of SEM because kurtosis impacts tests of variances and covariances, whereas skewness has a greater impact on means. The c.r column contains critical ratios for testing the statistical significance of these values. The critical ratios are formed by taking the ratio of the estimate (for skew or kurtosis) to its standard error. The ratio is distributed as a "unit normal variate", or z-score. If the c.r value is between -1.96 to +1.96, the data is normally distributed at 95% confidence interval (alpha of 0.05) [173]. The c.r and previous rules of thumb can be applied to addressing the question of whether the data depart significantly from multivariate normality. Nevertheless, multivariate kurtosis values >5 can be treated as indicative of departure from multivariate normality [174]. Cut-off values for the normality have been mentioned in **Table 3.15**.

Table 3.15: Normality Values [172 - 174]

Terms	**Values**
Skew	<3
Kurtosis	<7
c.r	$< \pm 1.96$
Multivariate Kurtosis	<5
Multivariate c.r	$<\pm .96$

3.3.8 Multi-Collinearity Analysis

Multi-collinearity explains the intercorrelation between the variables and it is problematic, has the potential to impact the statistical significance of variables and makes it difficult to assess the significant impact of the independent variable to explain variation in the dependent variable. Therefore, multicollinearity tests were conducted through collinearity statistics (Tolerance analysis and Variable Inflation Factor) and collinearity diagnostics (Eigen values and condition index) [175, 176]. Tolerance value (1-R^2) below 0.1 requires the attention of the researcher and a value below 0.2 is the cause of concern [177, 178]. The standard value of tolerance ranges from 0 to 1, where a higher tolerance value (close to 1) indicates low multicollinearity and a low tolerance value (close to 0) shows high multicollinearity [179]. Similarly, a tolerance value above 10 also shows high multicollinearity [180]. When independent variables are correlated, the variable inflation factor (VIF) assesses an increase in the variance of a regression coefficient [181]. Further, if VIF (1/Tolerance) estimate is equal to or greater than 5, the reporting variable should be removed due to high multicollinearity [182]. In case of no inter-correlation, the VIF value will be 1, thus, the higher the value of VIF, the higher will be the multicollinearity [183]. For no multicollinearity among the variables, the Eigen value must not be close to zero (0.001) and the condition index value should be less than 15 [184, 185]. Multicollinearity is tested by these four values mentioned above and all cut-ff values for collinearity have been presented in Table 3.16.

TABLE 3.16: Multi-collinearity cut-off values [177 – 180, 182, 184, 185]

Indicators	**Collinearity Statistics**		**Collinearity Diagnostics**	
	Tolerance	**VIF**	Eigenvalue	**Condition Index**
Threshold values	> 0.2	< 5.0	not close to zero	< 15

3.3.9 Correlation Coefficient Analysis

In statistics, correlation is a measure that determines the degree to which two or more random variables move in sequence. When an equivalent movement of another variable reciprocates the movement of one variable in some way or another during the study of two variables, the variables are said to be correlated [186]. The formula for calculating the correlation coefficient (r) is

$$r = \frac{Cov(x,y)}{\sqrt{Var(x)Var(y)}}$$

Where; var (x) and var (y) are standard deviations of x and y respectively [187]. Positive correlation occurs when two variables move in the same direction. When variables move in the opposite direction, they are said to be negatively correlated [188]. Correlation is of three types; the first is a simple correlation in which a single number expresses the degree to which two variables are related. The second is a partial correlation in which when one variable's effects are removed, and the correlation between two variables is revealed in partial correlation. The third is multiple correlation which uses two or more variables to predict the value of one variable [189]. Similarly, the correlation coefficient is of many types but the most common are; Pearson and Spearman correlation [190].

The Pearson correlation coefficient measures how well two continuous variables are related linearly. The Spearman correlation coefficient is based on the ranking values for each variable rather than raw data. When evaluating correlations between ordinal variables, the Spearman correlation coefficient is typically utilised [191]. Correlation coefficient assessment is an extensively and commonly applied statistical test which describes the degree of interdependence between two quantitative variables. However, the relational association between these variables may not be an outcome of any causal relationship [192]. Correlation analysis indicates the high and weak relationships of the variables; where a high correlation shows that variables are strongly related to each other, and a weak correlation refers that variables are hardly related to each other [193]. Correlation coefficient analysis is also used to identify any underlying patterns or trends in the dataset [194].

3.3.10 Effect Size Analysis

The magnitude of an effect is a measurement of how strong a relationship exists between two variables [195]. Cohen's f statistic is a good effect size measure to use in a one-way analysis of variance (ANOVA). Cohen's f is a statistic that measures the population's average influence at all levels of the independent variable. Cohen's f can take on any value between zero and an arbitrarily high value when the standard deviation of means rises relative to the average standard deviation within each group. The larger the effect size, the stronger the link between two variables. Cohen's f is calculated as [196]:

$$\text{Cohen's f} = \sqrt{\frac{\eta^2}{1-\eta^2}}$$

3.3.11 Hypothesis Testing

After doing each analysis mentioned above, all hypotheses were tested based on the estimates of structural paths (β, C.R, and P values). Two variables are positively and negatively associated with each other if the estimation value (β) is positive and negative respectively. CR value $> \pm 1.96$ indicates a stronger relationship between the variables. Their relationship is significant if the P value is < 0.05, otherwise, it is insignificant. The strength of the relationship between the variables is determined by the results of the effect size analysis. Cohen's f values of 0.10, 0.25 and 0.40 represent small, medium and large effect sizes [197]. The larger the effect size, the stronger the relationship between variables. A hypothesis is accepted only if variables are positively and significantly associated with each other.

3.4 Chapter Summary

This study highlighted the innovative role of health and safety management among the employees at the construction sites in Pakistan. It discussed the tools and techniques for data collection and its analysis. It also detailed the methods used to conduct the analysis. The details of the hypotheses for the study are also included in this chapter along with a flow chart of the methodology adopted.

Chapter 4

Results, Analysis and Discussion

4.1 Introduction

Demographic analysis and descriptive analysis were performed to understand the impact of the lean culture in the management of health safety for construction projects. It helped to understand the process through which the lean management of cultures can help to improve the health safety management in construction sites in this country.

Health safety is an essential thing in construction sites therefore the demographic as well as descriptive analysis helped to develop the safety precautions to improve the project quality in Pakistan. Lean culture and innovation model help to innovate the project factors including health and safety management to maintain a safe environment effectively. This chapter details the results achieved as a result of the methodology adopted.

It details the details of demographic analysis, reliability of data, type of data achieved and its subsequent testing. It also provides in detail the impact of identified factors on lean culture's role in our health and safety management on construction projects.

This was achieved by adopting SEM. Based on the results, necessary discussions have also been presented in this chapter.

4.2 Analysis of Data

According to the recent attention to the characteristics of lean implementation, this study investigates the composite and dimensional model of lean culture. Literature suggests that a composite form of lean culture produces an affirmative healthy and safe working environment [198]. Though the majority of lean literature is nurtured in Western society, hence, this study aims to examine the composite form of lean culture with lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement.

4.2.1 Demographic Analysis

Demographic analysis helps understand the characters of the respondents in this study as well as through the demographic analysis all the responses of respondents and their impacts are found in this study. **Figure 4.1** shows the educational qualifications of 462 respondents in this study. Based on the above tables it is found that 214 (46.1%) of respondents are from bachelor's degree backgrounds. 114 (25.1%) of the total respondents are from MS educational backgrounds in this study. 97 (21.2%) participants have PhD. 37 (8%) respondents were presented from other education levels.

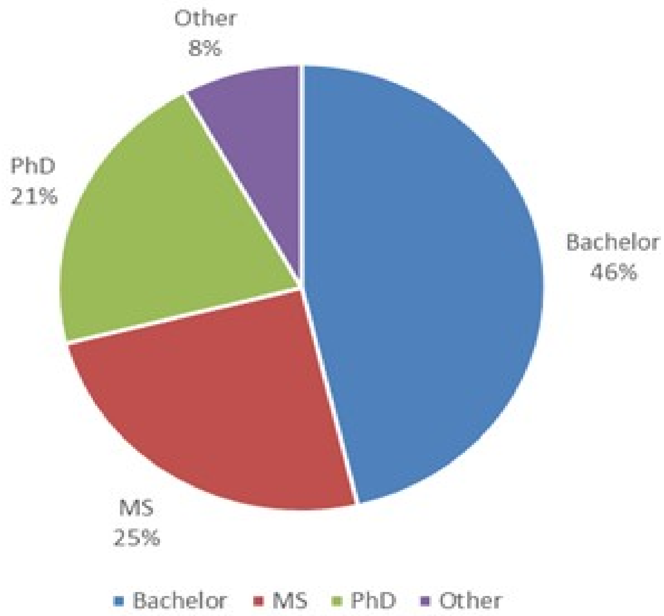


FIGURE 4.1: Qualification of Respondents

Figure 4.2 shows the professional experiences of all the respondents and the analysis of the above study shows that 163 (35%) of the respondents of the study have less than 5 years of professional experience. The stake holders contacted for the data collection comprises of construction employees, local contractors, consultants, construction managers, site engineers, design engineers, planning engineers and safety supervisors. A total of 550 questionnaires were distributed and 462 were received back with a response rate of 84%. Out of 462 respondents, 15.8% were contractors, 13.42% were consultants, 9.1% were construction managers, 16.45% were site-engineers, 14.72% were design engineers, 11.03% were planning engineers and 19.48% were safety supervisors. A total of 163 respondents, out of 462, were bearing experience of 5 years or less. And out of those 163, 141 respondents had 4 years of working experience, 18 respondents with 3 years of experience and 4 respondents with 2 years of experience. 122 (27%) of respondents of this study had working experience of 5 to 10 years which was very significant for this study. 100 (22%) respondents were having professional working experience of 11 years to 15 years. Apart from these, having 16 to 20 years of professional experience respondents are 62 (13%). Based on this figure, it was found that 15 (3%) of respondents were having working experiences of more than 20 years that positively impacted this study.

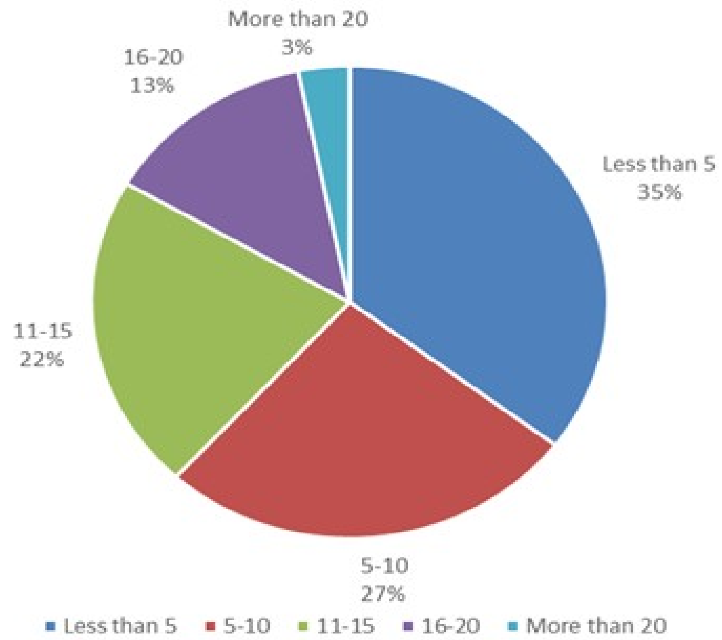


Figure 4.2: Experience (in years) of Respondents

Based on Figure 4.3, 60 (13%) respondents in this study are from the C6 firm category and on the other hand, 81 (18%) of respondents are from the C5 category of firms in this study. 75 (16%) of the respondents are from the C4 category of a firm in this study as well as 79 (17%) are from the firm category of C3. From the analysis of the above table, it is found that 61 (13%) of the respondents of the current study are from the C2 firm category and on the other hand 53 (11%) are from the C1 category of the firm effectively in this study. Respondents from the C-A 26 (6%), as well as 27 (6%) respondents, are from the others.

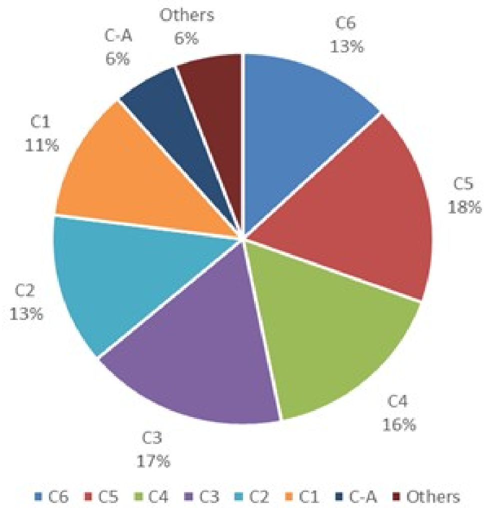


Figure 4.3: Types of Firms of Respondents

Based on figure 4.4, 426 (92%) of respondents are male in this study and 36 (8%) of respondents are female.

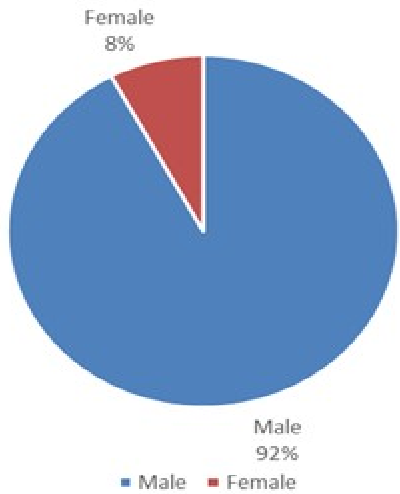


Figure 4.4: Gender of Respondents

4.2.2 Reliability Test

The concept of dependability is used to assess research quality. It shows how accurate a process or test is in measuring something. What dependability is all about is a metric's consistency. To ensure the questionnaire's reliability, Cronbach's alpha was utilised. The most often used internal consistency statistic is Cronbach's alpha. It's most typically used when there are a lot of Likert items in a survey or questionnaire that make up a scale and you want to know how reliable it is [199]. The reliability test is one of the fundamental tests conducted to verify the reliability of the data. This test is also known as Cronbach's alpha test. Cronbach's alpha test is a valuable analysis used to assess the reliability or internal consistency of any given data set [200].

4.2.2.1 Reliability Test for Variables of Lean Culture

There are 7 dependent variables in this work, so the reliability of each set of independent variables for a specific dependent variable has been separately tested. **Table 4.1** represents that all 462 responses are valid for the test of independent variables of lean culture.

Table 4.1: Case Processing Summary for Variables of Lean Culture

		N	%
Cases	Valid	462	100
	Excluded[a]	0	0
	Total	462	100

a. listwise delation based on all variables in the procedure.

Table 4.2 shows that the set of 12 independent variables of the dependent variable lean culture has Cronbach's Alpha of 0.928. As the value is greater than 0.9, so all independent variables have excellent reliability.

Table 4.2: Reliability Statistics for Variables of Lean Culture

Cronbach's Alpha	N of Items
0.928	12

TABLE 4.3: Item-Total Statistics for Variables of Lean Culture

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
LC1	39.49	66.821	0.67	0.923
LC2	39.2	62.455	0.607	0.930
LC3	39.34	67.324	0.684	0.923
LC4	39.14	63.84	0.693	0.922
LC5	39.23	66.235	0.724	0.921
LC6	39.27	64.793	0.762	0.919
LC7	39.18	66.484	0.767	0.920
LC8	39.31	66.794	0.706	0.922
LC9	39.09	68.178	0.619	0.925
LC10	39.23	65.944	0.747	0.920
LC11	39.34	64.291	0.794	0.918
LC12	39.14	64.649	0.682	0.923

But the value can be increased or decreased yet. **Table 4.3** represents if any independent variable of lean culture is deleted, how much would be the value of a set of remaining independent variables. Like if LC2 gets deleted, the value of 11 independent variables would be 0.930. But as the value is already excellent, so there is no need to delete any independent variable for further analysis. All 12 independent variables of lean culture are retained.

4.2.2.2 Reliability Test for Variables of Lean Leadership

Table 4.4 represents that all 462 responses are valid for the test of independent variables of lean leadership.

Table 4.4: Case Processing Summary for Variables of Lean Leadership

		N	%
Cases	Valid	462	100
	Excluded[a]	0.000	0.000
	Total	462	100

a. listwise delation based on all variables in the procedure.

Table 4.5 shows that the set of 14 independent variables of the dependent variable lean leadership has Cronbach's Alpha of 0.958. As the value is greater than 0.9, so all independent variables have excellent reliability.

Table 4.5: Reliability Statistics for Variables of Lean Leadership

Cronbach's Alpha	N of Items
0.958	14

But the value can be increased or decreased yet. **Table 4.6** represents if any independent variable of lean leadership is deleted, how much would be the value of a set of remaining independent variables. But as the value is already excellent, so there is no need to delete any independent variable for further analysis. All 14 independent variables of lean leadership are retained.

Table 4.6: Item-Total Statistics for Variables of Lean Leadership

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
LL1	47.28	101.057	0.768	0.955
LL2	47.08	105.14	0.731	0.956
LL3	46.96	101.558	0.793	0.954
LL4	46.84	104.631	0.734	0.955
LL5	47.02	107.468	0.677	0.957
LL6	47	100.548	0.829	0.953
LL7	47.02	105.779	0.746	0.955
LL8	46.8	105.614	0.682	0.957
LL9	47.06	105.158	0.764	0.955
LL10	47.14	103.382	0.819	0.954
LL11	47.13	103.609	0.795	0.954
LL12	46.91	103.376	0.814	0.954
LL13	47.16	103.556	0.824	0.954
LL14	47.15	103.443	0.811	0.954

4.2.2.3 Reliability Test for Variables of Teamwork

Table 4.7 represents that all 462 responses are valid for the test of independent variables of teamwork.

Table 4.7: Case Processing Summary for Variables of Teamwork

		N	%
	Valid	462	100
Cases	Excluded[a]	0	0
	Total	462	100

a. Listwise deletion based on all variables in the procedure.

Table 4.8 shows that the set of 5 independent variables of the dependent variable teamwork has Cronbach's Alpha of 0.906. As the value is greater than 0.9, so all independent variables have excellent reliability.

Table 4.8: Reliability Statistics for Variables of Teamwork

Cronbach's Alpha	**N of Items**
0.906	5

But the value can be increased or decreased yet. **Table 4.9** represents if any independent variable of teamwork is deleted, how much would be the value of a set of remaining independent variables. If any independent variable gets deleted, the value would be decreased to lower than 0.9. But as the value is already excellent, so there is no need to delete any independent variable for further analysis. All 5 independent variables of teamwork are retained.

4.2.2.4 Reliability Test for Variables of Management Role

Table 4.10 represents that all 462 responses are valid for the test of independent variables of management role.

Table 4.9: Item-Total Statistics for Variables of Teamwork

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
TW1	13.84	12.008	0.748	0.889
TW2	13.83	12.503	0.758	0.887
TW3	13.75	11.292	0.799	0.879
TW4	13.85	12.374	0.747	0.889
TW5	13.72	12.292	0.777	0.883

Table 4.10: Case Processing Summary for Variables of Management Role

		N	%
Cases	Valid	462	100
	Excluded[a]	0	0
	Total	462	100

a. Listwise deletion based on all variables in the procedure.

Table 4.11 shows that the set of 10 independent variables of the dependent variable management role has Cronbach's Alpha of 0.940. As the value is greater than 0.9, so all independent variables have excellent reliability.

Table 4.11: Reliability Statistics for Variables of Management Role

Cronbach's Alpha	**N of Items**
0.94	10

But the value can be increased or decreased yet. **Table 4.12** represents if any independent variable of management role is deleted, how much would be the value of a set of remaining independent variables. But as the value is already excellent, so there is no need to delete any independent variable for further analysis. All 10 independent variables of management role are retained.

4.2.2.5 Reliability Test for Variables of Social Responsibility

Table 4.13 represents that all 462 responses are valid for the test of independent variables of social responsibility.

Table 4.12: Item-Total Statistics for Variables of Management Role

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
MR1	32.17	48.315	0.811	0.93
MR2	32.12	48.717	0.842	0.929
MR3	32.1	48.938	0.826	0.93
MR4	31.82	49.774	0.735	0.934
MR5	32.06	52.112	0.65	0.938
MR6	32.17	47.279	0.807	0.931
MR7	31.82	49.864	0.746	0.934
MR8	32.13	48.063	0.771	0.933
MR9	31.97	51.976	0.676	0.937
MR10	32.07	51.593	0.68	0.937

Table 4.13: Case Processing Summary for Variables of Social Responsibility

		N	**%**
Cases	Valid	462	100
	Excluded[a]	0	0
	Total	462	100

a. Listwise deletion based on all variables in the procedure.

Table 4.14 shows that the set of 4 independent variables of the dependent variable social responsibility has Cronbach's Alpha of 0.890. As the value is greater than 0.7, so all independent variables have good reliability.

Table 4.14: Reliability Statistics for Variables of Social Responsibility

Cronbach's Alpha	**N of Items**
0.89	4

But the value can be increased or decreased yet. **Table 4.15** represents if any independent variable of social responsibility is deleted, how much would be the value of a set of remaining independent variables. If any independent variable gets deleted, the value would be decreased. But as the value is already good, so there is no need to delete any independent variable for further analysis. All 10 independent variables of social responsibility are retained.

Table 4.15: Item-Total Statistics for Variables of Social Responsibility

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
SR1	10.88	5.676	0.74	0.87
SR2	10.73	5.851	0.819	0.835
SR3	10.59	6.762	0.733	0.871
SR4	10.64	6.137	0.764	0.857

4.2.2.6 Reliability Test for Variables of Working Environment

Table 4.16 represents that all 462 responses are valid for the test of independent variables of working environment.

Table 4.16: Case Processing Summary for Variables of Working Environment

		N	%
Cases	Valid	462	100
	Excluded[a]	0	0
	Total	462	100

a. Listwise deletion based on all variables in the procedure.

Table 4.17 shows that the set of 11 independent variables of the dependent variable working environment has Cronbach's Alpha of 0.942. As the value is greater than 0.9, so all independent variables have excellent reliability.

Table 4.17: Reliability Statistics for Variables of Working Environment

Cronbach's Alpha	N of Items
0.942	11

But the value can be increased or decreased yet. **Table 4.18** represents if any independent variable of working environment is deleted, how much would be the value of a set of remaining independent variables. If any independent variable gets deleted, the value would be decreased. But as the value is already excellent, so there is no need to delete any independent variable for further analysis. All 11 independent variables of working environment are retained.

Table 4.18: Item-Total Statistics for Variables of Working Environment

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
WE1	36.51	66.111	0.731	0.937
WE2	36.26	64.786	0.767	0.936
WE3	36.42	66.958	0.666	0.939
WE4	36.47	59.697	0.817	0.934
WE5	36.41	67.45	0.67	0.939
WE6	36.38	61.809	0.818	0.933
WE7	36.6	62.722	0.753	0.936
WE8	36.41	62.349	0.816	0.933
WE9	36.46	66.695	0.704	0.938
WE10	36.44	66.493	0.711	0.938
WE11	36.38	62.205	0.799	0.934

4.2.2.7 Reliability Test for Variables of Auditing and Continuous Improvement

Table 4.19 represents that all 462 responses are valid for the test of independent variables of auditing and continuous improvement.

Table 4.19: Case Processing Summary for Variables of Auditing and Continuous Improvement

		N	%
	Valid	462	100
Cases	Excluded[a]	0	0
	Total	462	100

a. Listwise deletion based on all variables in the procedure.

Table 4.20 shows that the set of 9 independent variables of the dependent variable auditing and continuous improvement have Cronbach's Alpha of 0.924. As the value is greater than 0.9, so all independent variables have excellent reliability.

Table 4.20: Reliability Statistics for Variables of Auditing and Continuous Improvement

Cronbach's Alpha	N of Items
0.924	9

But the value can be increased or decreased yet. **Table 4.21** represents if any independent variable of auditing and continuous improvement is deleted, how much would be the value of a set of remaining independent variables. If any independent variable gets deleted, the value would be decreased. But as the value is already excellent, so there is no need to delete any independent variable for further analysis. All 9 independent variables of auditing and continuous improvement are retained.

Table 4.21: Item-Total Statistics for Variables of Auditing and Continuous Improvement

	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
AC1	28.81	33.215	0.747	0.915
AC2	28.73	36.78	0.683	0.918
AC3	28.72	36.901	0.695	0.918
AC4	28.79	37.05	0.642	0.92
AC5	28.87	33.878	0.751	0.914
AC6	28.84	34.811	0.773	0.912
AC7	28.77	36.358	0.722	0.916
AC8	28.77	36.175	0.72	0.916
AC9	29	32.501	0.84	0.908

4.2.2.8 Reliability Test Summary

In addition to the aforementioned criteria in **Table 3.12**, the total number of items in a measure also influences the alpha reliability of a scale. Though a higher value of Cronbach's alpha indicates high confidence in the measure. However, the alpha reliability for a multi-dimensional construct might be inferior and requires to be ascertained by conducting a factor structure analysis to determine scale item loading [201]. A summary of scale reliability is presented in **Table 4.22**.

Table 4.22: Summary of Reliability Test

Dependent Variables	**Alpha Value**	**Total Items**	**Items Retained**
Lean Culture	0.928	12	12
Lean Leadership	0.958	14	14
Teamwork	0.906	5	5
Management Role	0.94	10	10
Social Responsibility	0.89	4	4
Working Environment	0.942	11	11
Auditing and Continuous Improvement	0.924	9	9

4.2.3 Normality Test

A normally distributed data or data normality indicates a perfect symmetry of data around its mean. Data normality examination is the prerequisite to various statistical tests [202].

4.2.3.1 Skewness & Kurtosis

Data normality evaluation before hypothesis testing allows for certification and avoids deceitful test results. Generally, to assess the data normality for main variables, Kurtosis and Skewness tests are performed. Kurtosis indicates a bell peak, where light tails indicate low kurtosis and heavy tails signifies a high value of kurtosis. Whereas, skewness also shows data normality using a curve, where if a curve is tilted towards left or right is referred to as skewed data [203]. In this case n = 462 (> 300), so if the value of skewness is greater than 2, the dataset is away from the normally distributed sample, and it is recommended to normalize the data before further testing. Also, any kurtosis value which is greater than 7 is an indication of data non-normality [204]. The analysis includes lean culture as a composite variable. **Table 4.23** represents the skewness and kurtosis estimates of the collected data.

Table 4.23: Normality Test

Main Variables	**Skewness**		**Kurtosis**	
	Statistic	**Std. Error**	**Statistic**	**Std. Error**
Lean Culture	0.012	0.114	-0.78	0.227
Lean Leadership	-0.011	0.114	-0.435	0.227
Teamwork	-0.026	0.114	-0.661	0.227
Management Role	-0.034	0.114	-0.861	0.227
Social Responsibility	-0.056	0.114	-0.911	0.227
Working Environment	0.055	0.114	-0.906	0.227
Auditing and Continuous Improvement	-0.173	0.114	-0.635	0.227

The skewness value for this study ranges between -.911 to +.055, which are less than 2. Also, the kurtosis value is not greater than 7, so the sample data is normally distributed.

4.2.4 One Way ANOVA Test

Previous research studies recommended for examining the relational association of demographic and work-related variables before testing the hypotheses to analyse the impact of demographic variables on criterion variables [205]. Therefore, this study investigates the pattern of association between demographic and work-related variables on the dependent variables of the study including lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement through theoretical support and statistical analysis. This study includes four demographical and work-related variables i.e., qualification, experience, firm category and gender. To examine any relational association of demographic and work-related variables on the criterion variables of this study, the One-way analysis of variance (ANOVA) test was conducted. ANOVA test is commonly used to identify an association between the criterion variables with demographic and work-related control variables [206]. Details of this analysis are shown in **Table 4.24**. Results indicate a mix results for the differences which exits between the demographic groups, for example qualification was found significant with lean leadership F (3, 458) = 10.775, p = .000, η^2 = .066, working environment F (3, 458) = 4.228, p = .006, η^2 = .027 and auditing and continuous improvement F (3, 458) = 3.828, p = .010, η^2 = .024; while experience was significant with lean leadership F (4, 457) = 5.387, p = .000, η^2 = .045, teamwork F (4, 457) = 7.487, p = .000, η^2 = .062, social responsibility F (4, 457) = 4.498, p = .001, η^2 = .038 and working environment F (4, 457) = 4.548, p = .001, η^2 = .038; firm category was found significant with lean leadership F (7, 454) = 5.634, p = .000, η^2 = .080, teamwork F (7, 454) = 2.700, p = .009, η^2 = .040, management role F (7, 454) = 3.441, p = .001, η^2 = .050, social responsibility F (7, 454) = 2.038, p = .049, η^2 = .030, working environment F (7, 454) = 3.374, p = .002, η^2 = .049 and auditing and continuous improvement F (7, 454) = 2.922, p = .005, η^2 = .043, while rest of the other correlations between gender and the dependent variables were insignificant. Similarly, all other correlations between qualification, experience, firm category and the dependent variables were also insignificant. Therefore, these demographic variables were controlled while testing the hypotheses. ANOVA results are presented in **Table 4.24**.

Table 4.24: One-Way ANOVA Test

	Qualification			**Experience**			**Firm Category**			**Gender**		
	F	Sig.		F	Sig.		F	Sig.		F	Sig.	
LL	10.775	0.000	0.066	5.387	0.000	0.045	5.634	0.000	0.080	0.379	0.538	0.001
TW	1.961	0.123	0.013	7.487	0.000	0.062	2.700	0.009	0.04	0.026	0.873	0.000
MR	1.824	0.146	0.011	0.791	0.534	0.008	3.441	0.001	0.05	1.186	0.277	0.003
SR	1.833	0.144	0.011	4.498	0.001	0.038	2.038	0.049	0.03	1.529	0.217	0.003
WE	4.228	0.006	0.027	4.548	0.001	0.038	3.374	0.002	0.049	0.085	0.771	0.000
AC	3.828	0.01	0.024	1.733	0.15	0.016	2.922	0.005	0.043	2.697	0.101	0.006

4.2.5 Exploratory Factor Analysis (EFA)

Usually, Bartlett's Test of Sphericity is performed using a data reduction technique of EFA. Bartlett's test assumes two hypotheses, where the null hypothesis analyses that variables are not correlated, while the alternate hypothesis examines that variables are enough correlated to diverge from the identity matrix. Any value of Bartlett's test below .5 is appreciated [207]. Bartlett's estimate for this study is .000. Results of EFA analysis also produce a table indicating the estimates of communalities; this test indicates the aggregate variance reported by each variable. In other words, communalities ensure reliability through the extent to which an item inter-correlates with other items. A high communality value indicates better item loading results, while a low degree of communality indicates that a particular variable may find it difficult to load on any factor [208]. The table of communalities in this study shows a value below 1, and the value of variance explained is above .5. Thus, standard criteria are met. Results of KMO and Bartlett's test have been presented in **Table 4.25**. KMO value obtained, .853; indicates that sampling data is meritorious according to the aforementioned criteria in **Table 3.13**.

Table 4.25: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0.853**
Bartlett's Test of Sphericity	Approx. Chi-Square	22287.077
	df	2080
	Sig.	.000

Table 4.26 represents the factor analysis of lean culture and outcome variables, i.e., lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement, with 65 items in total. EFA results indicate 17 factors extracted. Zhang [209] identified a standard criterion for factor loading as an estimate of 0.3. Thus, any value below 0.3 was suppressed, and was not made part of the rotated solution; further, these values were not presented in the final solution. The details of item loading are summarized below.

TABLE 4.26: Rotated Component Matrix

	Component																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LC1	0.624																
LC2													0.421				
LC3	0.53																
LC4	0.717																
LC5	0.734																
LC6	0.661																
LC7	0.577									0.417							
LC8										0.544							
LC9										0.729							
LC10										0.444			0.41				
LC11													0.613				
LC12													0.678				
LL1		0.51															
LL2												0.701					
LL3												0.601					
LL4									0.72								
LL5									0.64								
LL6			0.4						0.52								
LL7			0.6														
LL8			0.7														
LL9			0.7														

Continued Table 4.26 Rotated Component Matrix

	Component																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LL10			0.4														
LL11														0.688			
LL12			0.4											0.527			
LL13			0.7														
LL14												0.48					
TW1							0.537										
TW2							0.752										
TW3							0.554										
TW4									0.45								
TW5		0.48															
MR1		0.72															
MR2		0.57															
MR3		0.52															
MR4		0.51															
MR5																0.55	
MR6		0.62															
MR7																0.5	
MR8		0.76															
MR9				0.54													
MR10				0.48													
SR1				0.49													
SR2				0.55													
SR3				0.5													

Continued Table 4.26 Rotated Component Matrix

	Component																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SR4				0.78													
WE1								0.6									
WE2								0.68									
WE3								0.77									
WE4															0.474		
WE5															0.801		
WE6															0.418		
WE7											0.413						-0.524
WE8					0.535												
WE9					0.725												
WE10					0.661												
WE11					0.49											0.45	
AC1					0.468												
AC2					0.538												
AC3											0.725						
AC4											0.758						
AC5						0.456		0.54									
AC6						0.521											
AC7						0.638											
AC8						0.712											
AC9						0.714											

4.2.6 Structural Equation Modelling (SEM)

4.2.6.1 Model Fit

Hudek, et al. [210] state that EFA is an imperative precursor of CFA and conducting both analyses in one study supports confirming the underlying factor structure and patterns. Therefore, this study conducts more than one CFA analysis for the model to validate the factor analysis and its outcomes. Thus, CFA analysis was carried out through the AMOS technique. Confirmatory Factor Analysis is a significant and commonly used approach to validate the factor structure of the measured/observed variables under study. Results of CFA analysis are assessed by using estimates of different fit indices, i.e., chi-squared (χ^2), Comparative fit indices (CFI), Tucker-Lewis fit indices (TLI), Incremental fit indices (IFI), Root Mean Square Error

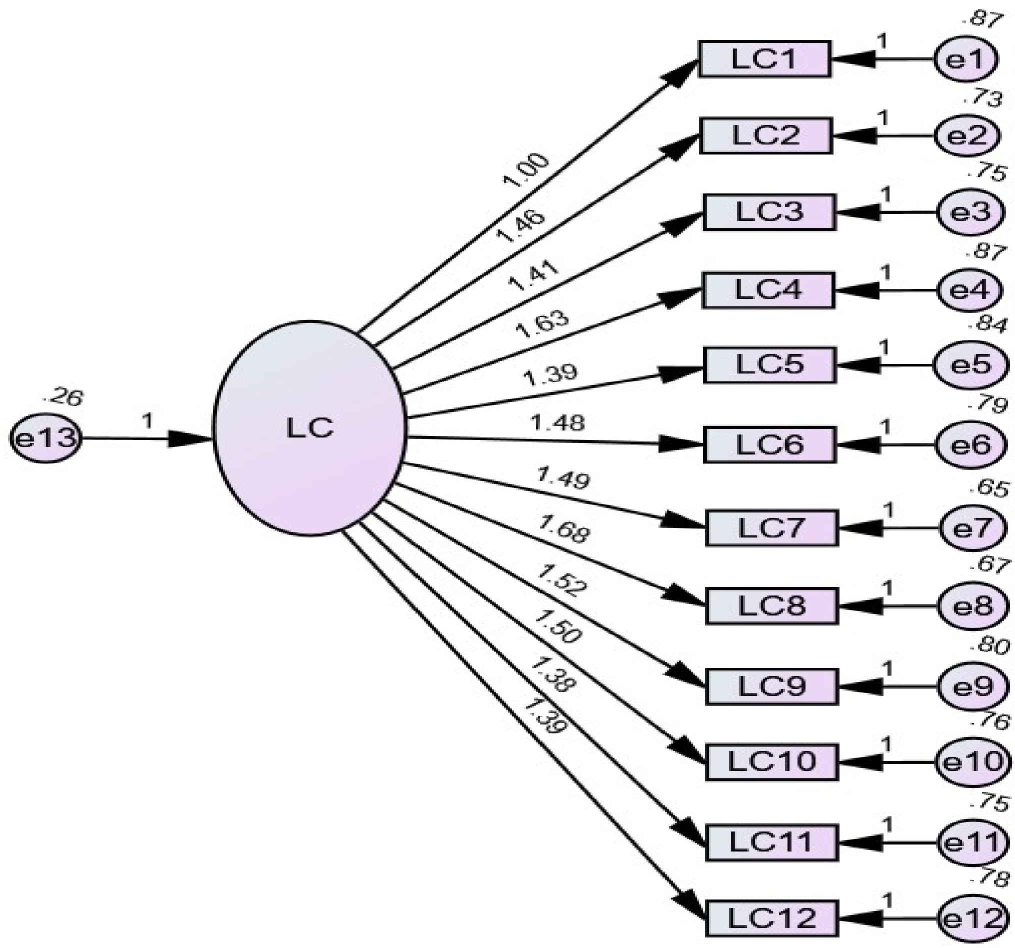


Figure 4.5: First order CFA

(CFI), Tucker-Lewis fit indices (TLI), Incremental fit indices (IFI), Root Mean Square Error of Approximation (RMSEA), and non-normed fit indices (NNFI) [211]. This study has examined various CFA analyses including first-order CFA of lean culture, second-order CFA of the measurement model and, lastly, a combined measurement model of all the measured/observed variables. As discussed in Chapter 3, only generally accepted model fit indicators are reported in this research study, which are χ^2/df, GFI, AGFI, NFI, TLI, CFI and RMSEA.

4.2.6.2 First Order Confirmatory Factor Analysis of Lean Culture

Confirmatory factor analysis (CFA) is a statistical approach which is used to verify the factor structure of the dataset which is composed of observed variables. Further, CFA helps in the better conceptualization of observed variables and their interpretation. CFA analysis enables to accurately examine the hypothetical relationship between observed and latent variables [151]. Primarily, lean culture was considered as a unidimensional construct followed by the identification of various dimensions of lean culture. To examine the first-order CFA of lean culture, all 12 indicators (items) were directly associated with the latent variable of lean culture (**Figure 4.5**, **Table 4.27**). Primarily, lean culture was considered as a unidimensional construct followed by the identification of various dimensions of lean culture. To examine the first-order CFA of lean culture, all 12 indicators (items) were directly associated with the latent variable of lean culture (Figure 4.5, **Table 4.27**). Results of first-order CFA converged into a good model-fit (χ^2/df = 1.387, GFI = .913, AGFI = .930, NFI = .913, TLI = .912, CFI = .909 and RMSEA = .076) and validates the construct validity through meeting the threshold values of all model-fit indices. Thus, the CFA results of the lean culture model fit were in line. Therefore, this study calculated the summated indexes on first-order CFA for further analysis.

4.2.6.3 Second Order Confirmatory Factor Analysis

While the second-order CFA was conducted by connecting all the indicators to their respective latent variable (**Figure 4.6, Table 4.28**). In Fig. 4.6, LL, TW,

Table 4.27: First Order CFA- Model Fit

Model	χ^2**/df**	**GFI**	**AGFI**	**NFI**	**TLI**	**CFI**	**RMSEA**
Threshold Values	< 2	$> .90$	$> .80$	$> .90$	$> .80$	≥ 0.90	$< .08$
Default	1.387	0.913	0.93	0.913	0.912	0.909	0.076

MR, SR, WE and AC are dependent variables. Each dependent variable is linked with its factors, which are measured variables. All the dependent variables are linked with each other through covariances. So, there are 15 covariances in this model. The model has 53 measured variables and each measured variable has a unique variable, so there are also 53 unique variables in this model.

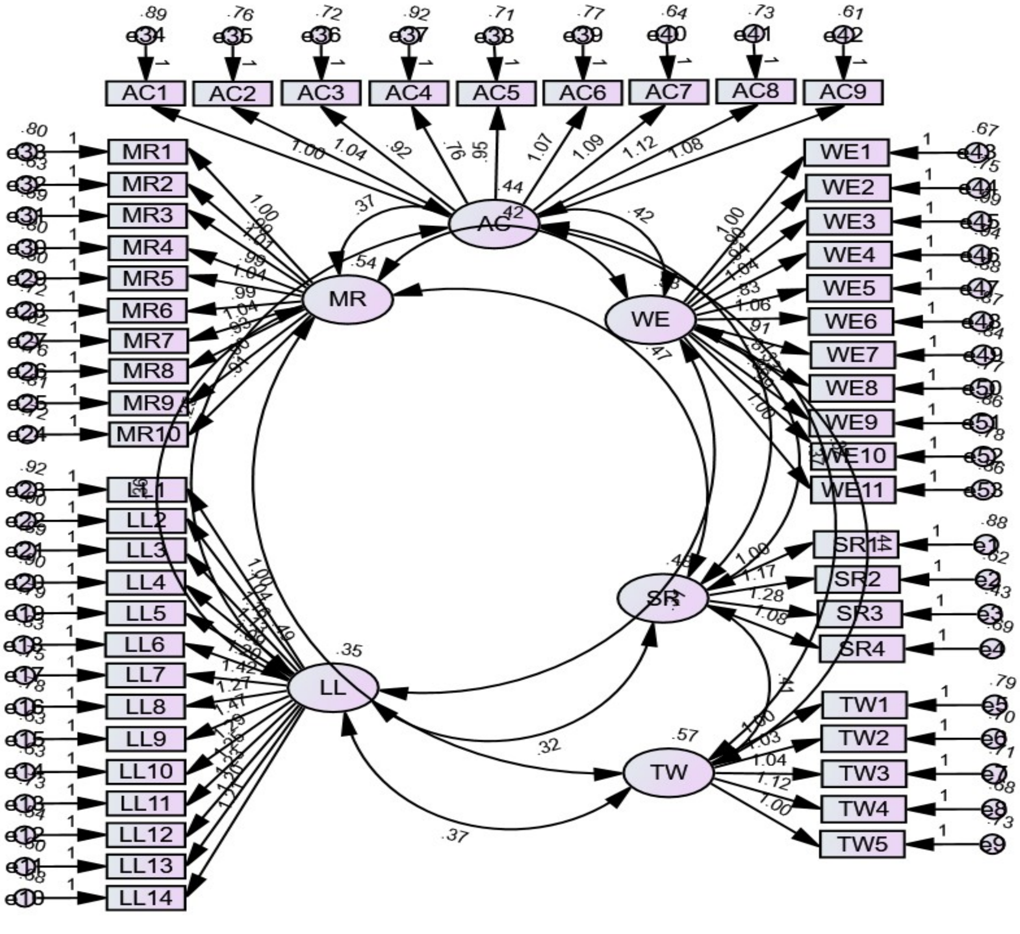


Figure 4.6: Second order CFA

Results of second-order CFA converged with significant fit of model (χ^2/df = 1.880, GFI = .939, AGFI = .906, NFI = .954, TLI = .917, CFI = .928 and RMSEA = .073). Therefore, no further post hoc modifications were made as all the threshold values were met.

Table 4.28: Second Order CFA- Model Fit

Model	**χ^2/df**	**GFI**	**AGFI**	**NFI**	**TLI**	**CFI**	**RMSEA**
Threshold Values	< 2	$> .90$	$> .80$	$> .90$	$> .80$	≥ 0.90	$< .08$
Default	1.88	0.939	0.906	0.954	0.917	0.928	0.073

4.2.6.4 Consolidated Confirmatory Factor Analysis

Lastly, a consolidated CFA was examined to observe a composite measurement model including all independent and dependent variables (Figure 4.7). Testing of such a complete measurement model is recommended by experts of CFA [212]. In Fig. 4.7, there are total 7 dependent variables, 65 measured variables, 66 error variances, 64 factor loadings, 6 factor variances and 15 covariances.

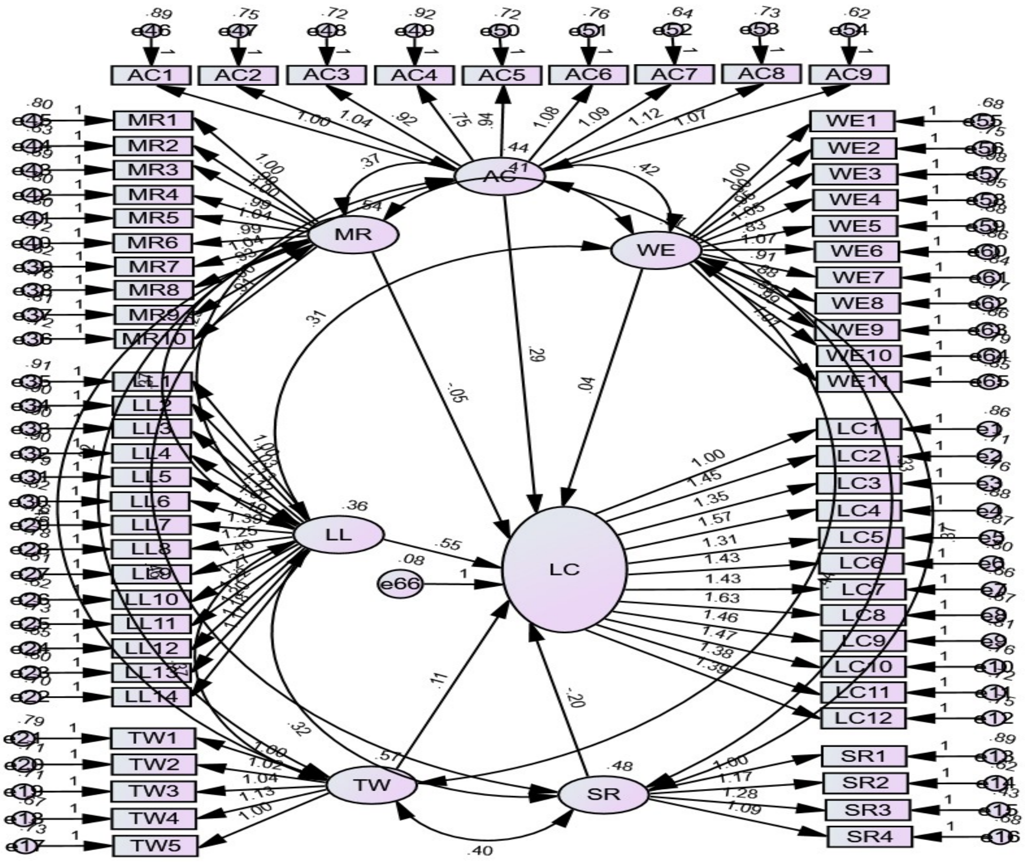


Figure 4.7: Consolidated CFA

Results of the consolidated CFA (**Figure 4.7**, **Table 4.29**) indicate almost acceptable fit of model values (χ^2/df = 2.03, GFI = .895, AGFI = .876, NFI = .902, TLI = .881, CFI = .889 and RMSEA = .081).

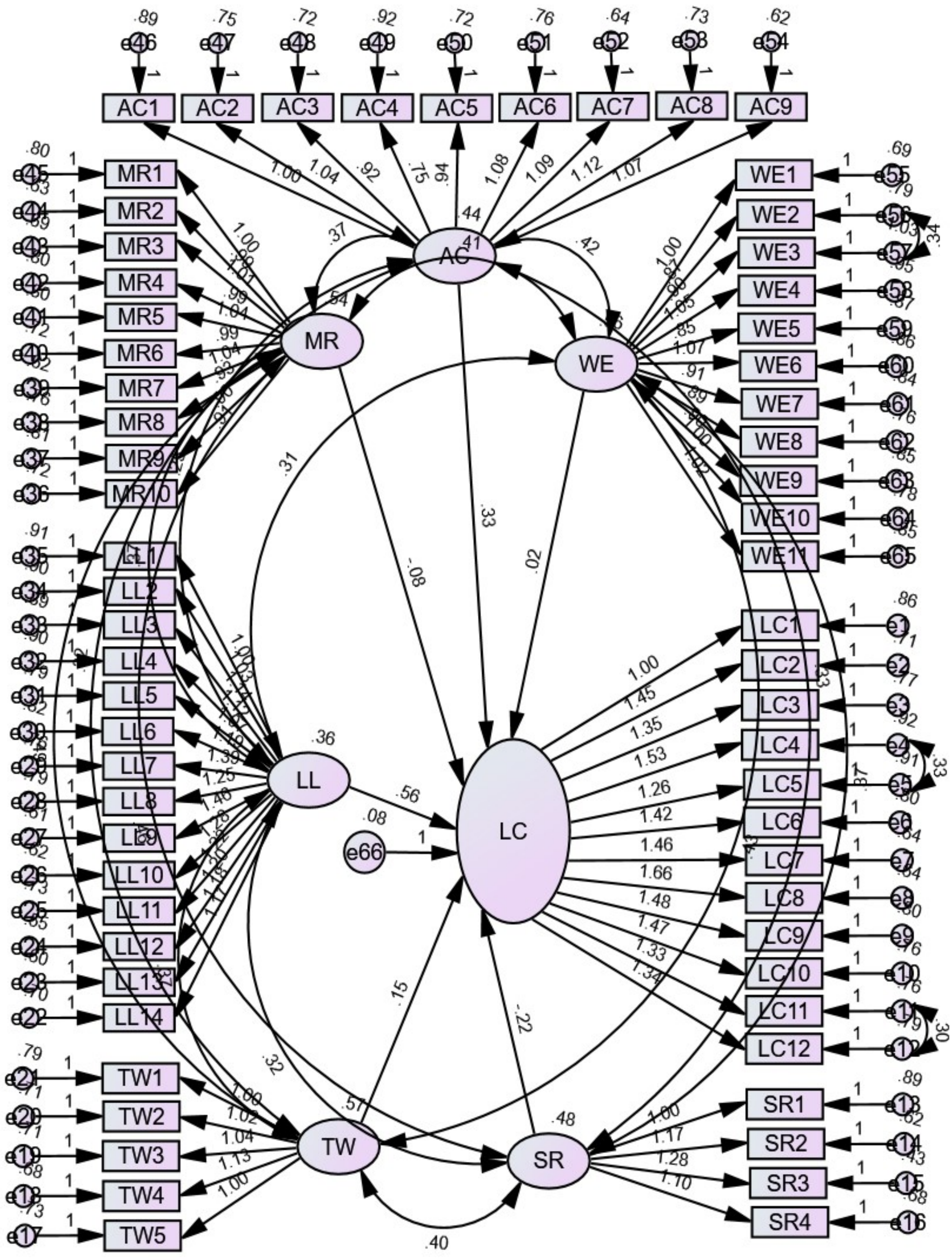


FIGURE 4.8: Complete Measurement Model

To achieve a superior fitting model, post hoc adjustments were made (**Figure 4.8**) to the initial model (Figure 4.7), by correlating error variables of the dependent variables, resulting in a good fit-model (χ^2/df = 1.903, GFI = .916, AGFI =

.905, NFI = .925, TLI = .902, CFI = .901 and RMSEA = .077). Thus, all the benchmark values are met (**Table 4.29**).

TABLE 4.29: Complete Measurement Model- Model Fit

Model	χ^2/**df**	**GFI**	**AGFI**	**NFI**	**TLI**	**CFI**	**RMSEA**
Threshold Values	< 2	> .90	> .80	> .90	> .80	≥ 0.90	< .08
Default (Consolidated CFA)	2.03	0.895	0.876	0.902	0.881	0.889	0.081
First Modification (e11 < − > e12)	1.99	0.901	0.881	0.91	0.889	0.893	0.08
Second Modification (e56 < − > e57)	1.951	0.909	0.892	0.917	0.895	0.897	0.078
Third Modification (e4 < − > e5)	1.903	0.916	0.905	0.925	0.902	0.901	0.077

After validating the fitness of the measurement model and construct validity, the analyses continued by calculating the composite variables of all the variables under investigation.

4.2.7 Univariate and Multivariate Normality

This normality test has been performed using Amos v23 and the model is fit as shown in above **Table 4.29**. In the assessment of normality, univariate normality for each observed variable and multivariate normality of the model can be seen in **Table 4.30**.

Based on the cut-off values for the normality mentioned in **Table 3.15**, it is quite clear that skewness and kurtosis values for each variable are less than 3 and 7 respectively. By examining c.r values of skewness and kurtosis, 15 and 59 variables

Table 4.30: Assessment of Normality

Variables	Min.	Max.	Skew	c.r.	Kurtosis	c.r.
SR3	1	5	-0.367	-3.223	-0.659	-2.889
SR4	1	5	-0.307	-2.693	-0.605	-2.656
SR2	1	5	-0.239	-2.094	-0.526	-2.307
SR1	1	5	-0.002	-0.018	-0.865	-3.794
LC1	1	5	0.021	0.182	-0.428	-1.876
LC2	1	5	-0.023	-0.199	-0.638	-2.797
LC3	1	5	-0.141	-1.235	-0.596	-2.616
LC4	1	5	-0.041	-0.361	-0.912	-4.002
LC5	1	5	-0.172	-1.511	-0.733	-3.216
LC12	1	5	-0.099	-0.865	-0.664	-2.912
LC11	1	5	-0.15	-1.315	-0.69	-3.027
LC10	1	5	-0.16	-1.403	-0.81	-3.553
LC9	1	5	-0.202	-1.773	-0.77	-3.38
LC8	1	5	-0.32	-2.811	-0.711	-3.121
LC7	1	5	-0.163	-1.427	-0.485	-2.128
LC6	1	5	-0.225	-1.973	-0.755	-3.312
WE11	1	5	-0.162	-1.423	-0.801	-3.513
LL14	1	5	-0.003	-0.025	-0.437	-1.919
LL13	1	5	-0.126	-1.105	-0.36	-1.581
LL12	1	5	-0.03	-0.267	-0.319	-1.399
LL11	1	5	-0.14	-1.229	-0.718	-3.149
AC4	1	5	-0.172	-1.507	-0.602	-2.642
AC5	1	5	-0.42	-3.688	-0.14	-0.614
AC6	1	5	-0.237	-2.081	-0.601	-2.639
AC7	1	5	-0.219	-1.924	-0.545	-2.391
AC8	1	5	-0.205	-1.796	-0.669	-2.936
AC9	1	5	-0.211	-1.85	-0.523	-2.293
AC2	1	5	-0.276	-2.424	-0.624	-2.737
AC3	1	5	-0.398	-3.492	-0.196	-0.859
AC1	1	5	-0.026	-0.227	-0.698	-3.062
TW1	1	5	-0.122	-1.074	-0.906	-3.975
TW2	1	5	-0.107	-0.937	-0.79	-3.467
TW3	1	5	-0.246	-2.16	-0.702	-3.078
TW4	1	5	-0.339	-2.976	-0.689	-3.023
TW5	1	5	-0.108	-0.952	-0.733	-3.217
LL10	1	5	-0.115	-1.01	-0.5	-2.192
LL9	1	5	-0.078	-0.689	-0.846	-3.714
LL8	1	5	-0.275	-2.41	-0.667	-2.925
LL6	1	5	-0.021	-0.183	-0.709	-3.11
LL7	1	5	-0.358	-3.138	-0.677	-2.97
LL5	1	5	-0.254	-2.226	-0.553	-2.425
LL4	1	5	-0.199	-1.746	-0.748	-3.284
LL3	1	5	-0.165	-1.45	-0.774	-3.396
LL2	1	5	-0.351	-3.078	-0.567	-2.489
LL1	1	5	-0.054	-0.475	-0.678	-2.974

Continued Table 4.30 Assessment of Normality

Variables	**Min.**	**Max.**	**Skew**	**c.r.**	**Kurtosis**	**c.r.**
WE1	1	5	-0.225	-1.975	-0.602	-2.64
WE2	1	5	-0.214	-1.878	-0.727	-3.19
WE3	1	5	-0.285	-2.499	-0.713	-3.129
WE4	1	5	-0.234	-2.05	-0.872	-3.826
WE5	1	5	-0.229	-2.012	-0.564	-2.474
WE6	1	5	-0.119	-1.046	-0.943	-4.136
WE7	1	5	-0.342	-3	-0.624	-2.737
WE8	1	5	-0.146	-1.279	-0.671	-2.943
WE9	1	5	-0.226	-1.982	-0.742	-3.258
WE10	1	5	-0.312	-2.737	-0.819	-3.592
MR10	1	5	-0.223	-1.961	-0.501	-2.2
MR9	1	5	-0.082	-0.715	-0.603	-2.647
MR8	1	5	-0.248	-2.172	-0.486	-2.132
MR7	1	5	-0.152	-1.332	-0.523	-2.294
MR6	1	5	-0.169	-1.481	-0.66	-2.894
MR5	1	5	-0.211	-1.855	-0.786	-3.447
MR4	1	5	-0.192	-1.682	-0.669	-2.935
MR3	1	5	-0.121	-1.06	-0.648	-2.841
MR2	1	5	-0.093	-0.816	-0.731	-3.209
MR1	1	5	-0.144	-1.26	-0.97	-4.255
Multivariate					573.783	66.074

are away from univariate normality out of 65 variables. Similarly, the variables in this analysis reflect a significant departure from multivariate normality, as multivariate kurtosis and multivariate c.r values are much higher. So, if there is no normality for multivariate, outliers are there in the sample data and it is very important to remove outliers to achieve normality. Although Amos does not give information on univariate outliers, it does allow us to assess the presence of multivariate outliers in the data [213]. For each case, a squared Mahalanobis distance value is generated, along with test statistics that can be used in determining that a case represents a multivariate outlier. Mahalanobis distance is a distance measure of the given information from the centroid (i.e., multivariate mean) for the variables included in the analysis. Cases with Mahalanobis d-squared values are more likely to be multivariate outliers [214]. According to Kline [215], Mahalanobis d-squared is "distributed as a central chi-square statistic with degrees of freedom equal to the number of variables". They recommend a more conservative p-value, such as p¡0.001, when testing for statistical significance. Byrne [216] also notes that a multivariate outlier will end to be one whose Mahalanobis d-squared value departs substantially from the others within the dataset. Observations which are far from the centroid can be seen in **Table 4.31**.

Amos represents the Mahalanobis d-squared values in descending (rank) order, it can be seen the highest Mahalanobis d-squared value is 115.172 for cases 155 and 313. The p1 column contains p-values which are used to test whether the observation departs significantly from the centroid for the variables [217]. Using Kline's example ($p<0.001$), it can be seen that just some cases yielded statistical significance. But using an alpha value of 0.05, all test results are statistically significant. Given this result, it is apparent that significance testing cannot be used as a strategy for identifying potential multivariate outliers in this dataset. There is a potential break in the Mahalanobis d-squared values between observation 313 and 148, whereas the decrease in Mahalanobis d-squared values from observation 148 through the remainder of the cases appears more gradual. This suggests that case 313 might be considered a multivariate outlier. The p2 column contains p-values that are used to test the likelihood of "the ordered values of N being as far or further away from the centroid". Byrne states, "Although small numbers appearing in the first column (p1) are to be expected, small numbers in the second column (p2) are improbably far from the centroid under the hypothesis of normality".

4.2.8 Managing Outliers

If the data exhibits non-normality, various strategies can be adopted theoretically. First, detection and management of outlying cases and/or variables that fail to exhibit univariate normality. Second, using an estimation method that does not assume multivariate normality, such as ADF estimation, is not generally recommended, except for samples with 1000 to 5000 cases [218, 219]. As there are

Table 4.31: Mahalanobis Distance

Observation number	**Mahalanobis d-squared**	**p1**	**p2**
155	115.172	0	0.057
313	115.172	0	0.002
148	110.693	0	0.001
306	110.693	0	0
76	109.782	0	0
234	109.782	0	0
392	109.782	0	0
136	105.593	0.001	0
294	105.593	0.001	0
452	105.593	0.001	0
84	105.346	0.001	0
242	105.346	0.001	0
400	105.346	0.001	0
82	105.336	0.001	0
240	105.336	0.001	0
398	105.336	0.001	0
156	105.228	0.001	0
314	105.228	0.001	0
45	104.837	0.001	0
203	104.837	0.001	0
361	104.837	0.001	0
86	104.129	0.001	0
244	104.129	0.001	0
402	104.129	0.001	0
19	104.064	0.002	0
177	104.064	0.002	0
335	104.064	0.002	0
37	103.632	0.002	0
195	103.632	0.002	0
353	103.632	0.002	0
79	103.505	0.002	0
237	103.505	0.002	0
395	103.505	0.002	0
41	102.423	0.002	0
199	102.423	0.002	0
357	102.423	0.002	0
31	102.152	0.002	0
189	102.152	0.002	0
347	102.152	0.002	0
72	101.745	0.002	0
230	101.745	0.002	0
388	101.745	0.002	0
78	100.92	0.003	0
236	100.92	0.003	0

Continued Table 4.31 Mahalanobis Distance

Observation number	**Mahalanobis d-squared**	**p1**	**p2**
394	100.92	0.003	0
125	100.159	0.003	0
283	100.159	0.003	0
441	100.159	0.003	0
33	100.135	0.003	0
191	100.135	0.003	0
349	100.135	0.003	0
73	98.388	0.005	0
231	98.388	0.005	0
389	98.388	0.005	0
53	97.191	0.006	0
211	97.191	0.006	0
369	97.191	0.006	0
135	95.862	0.008	0
293	95.862	0.008	0
451	95.862	0.008	0
7	94.829	0.009	0
165	94.829	0.009	0
323	94.829	0.009	0
3	94.272	0.01	0
161	94.272	0.01	0
319	94.272	0.01	0
83	93.963	0.011	0
241	93.963	0.011	0
399	93.963	0.011	0
147	93.443	0.012	0
305	93.443	0.012	0
32	92.724	0.014	0
190	92.724	0.014	0
348	92.724	0.014	0
108	92.207	0.015	0
266	92.207	0.015	0
424	92.207	0.015	0
150	91.219	0.018	0
308	91.219	0.018	0
140	91.134	0.018	0
298	91.134	0.018	0
456	91.134	0.018	0
46	90.606	0.02	0
204	90.606	0.02	0
362	90.606	0.02	0

Continued Table 4.31 Mahalanobis Distance

Observation number	Mahalanobis d-squared	p1	p2
110	89.957	0.022	0
268	89.957	0.022	0
426	89.957	0.022	0
146	88.978	0.026	0
304	88.978	0.026	0
462	88.978	0.026	0
106	88.865	0.026	0
264	88.865	0.026	0
422	88.865	0.026	0
10	88.556	0.028	0
168	88.556	0.028	0
326	88.556	0.028	0
25	88.256	0.029	0
183	88.256	0.029	0
341	88.256	0.029	0

462 cases in this research work, this strategy cannot be adopted. Third, using corrected test statistics, such as Satorra-Bentler scaled chi-square statistic, but unfortunately, this is not available through Amos [220, 221]. Finally, bootstrapping procedures are adopted through Amos to deal with outliers [222-224]. As just one case has been displayed as an outlier, it was removed to achieve normality.

4.2.9 Multi-Collinearity Test

This study also examines the multi-collinearity of all the variables in the model before conducting the main analysis. Results of multi-collinearity statistics for all the variables have been examined based on the cut-off values mentioned in **Table 3.16**.

4.2.9.1 Educational Qualification (BD1)

Results of coefficients of educational qualification against six dependent variables are presented in **Table 4.32** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.32: Coefficients for Educational Qualification (BD1)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.33**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.33: Collinearity Diagnostics for Educational Qualification (BD1)

Model	Dimension	Eigen value	Condition Index	Variance Proportions (Constant)	LL	TW	MR	SR	WE	AC
	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.6	0.11	0.06	0.08
1	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.2 Professional Experience (BD2)

Results of coefficients of professional experience against six dependent variables are presented in **Table 4.34** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.34: Coefficients for Professional Experience (BD2)

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.35**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

TABLE 4.35: Collinearity Diagnostics for Professional Experience (BD2)

Model	Dimension	Eigen value	Condition Index	Variance Proportions (Constant)	LL	TW	MR	SR	WE	AC
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.6	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.3 Firm Category (BD3)

Results of coefficients of firm category against six dependent variables are presented in **Table 4.36** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.36: Coefficients for firm Category (BD3)

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.63	1.588

Collinearity diagnostics (**Table 4.37**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.37: Collinearity Diagnostics for Firm Category (BD3)

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions**						
				(Constant)	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.6	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.6	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.4 Gender (BD4)

Results of coefficients of gender against six dependent variables are presented in **Table 4.38** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.38: Coefficients for Gender (BD4)

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.39**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

TABLE 4.39: Collinearity Diagnostics for Gender (BD4)

Model	Dimension	Eigen value	Condition Index	Variance Proportions (Constant)	LL	TW	MR	SR	WE	AC
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.5 Lean Culture (LC)

Results of coefficients of lean culture against six dependent variables are presented in **Table 4.40** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.40: Coefficients for Lean Culture (LC)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.00		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.63	1.588

Collinearity diagnostics (**Table 4.41**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.41: Collinearity Diagnostics for Lean Culture (LC)

Model	Dimension	Eigen value	Condition Index	Variance Proportions						
				(Constant)	LL	TW	MR	SR	WE	AC
	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
1	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.6 Safe Working Environment (LC1)

Results of coefficients of safe working environment (LC1) against six dependent variables are presented in **Table 4.42** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.42: Coefficients for LC1

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.192	0.173		6.908	0.00		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.43**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.43: Collinearity Diagnostics for LC1

Model	Dimension	Eigen value	Condition Index	Variance Proportions (Constant)	LL	TW	MR	SR	WE	AC
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.7 Safety Officer (LC2)

Results of coefficients of safety officer (LC2) against six dependent variables are presented in **Table 4.44** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.44: Coefficients for LC2

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.63	1.588

Collinearity diagnostics (**Table 4.45**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

TABLE 4.45: Collinearity Diagnostics for LC2

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions (Constant)**	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.8 Reduced Health and Safety Hazards (LC3)

Results of coefficients of reduced health and safety hazards (LC3) against six dependent variables are presented in **Table 4.46** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.46: Coefficients for LC3

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.47**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.47: Collinearity Diagnostics for LC3

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions (Constant)**	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.9 Safety Training (LC4)

Results of coefficients of safety training (LC4) against six dependent variables are presented in **Table 4.48** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.48: Coefficients for LC4

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.63	1.588

Collinearity diagnostics (**Table 4.49**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.49: Collinearity Diagnostics for LC4

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions**						
				(Constant)	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.10 Safety Commitment (LC5)

Results of coefficients of safety commitment (LC5) against six dependent variables are presented in **Table 4.50** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.50: Coefficients for LC5

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.51**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

TABLE 4.51: Collinearity Diagnostics for LC5

Model	Dimension	Eigen value	Condition Index	Variance Proportions (Constant)	LL	TW	MR	SR	WE	AC
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.11 Safety Incentives (LC6)

Results of coefficients of safety incentives (LC6) against six dependent variables are presented in **Table 4.52** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.52: Coefficients for LC6

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.53**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.53: Collinearity Diagnostics for LC6

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions**						
				(Constant)	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.12 Safety Inspection and Monitoring (LC7)

Results of coefficients of safety inspection and monitoring (LC7) against six dependent variables are presented in **Table 4.54** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.54: Coefficients for LC7

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.55**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

TABLE 4.55: Collinearity Diagnostics for LC7

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions (Constant)**	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.13 Safety Awareness (LC8)

Results of coefficients of safety awareness (LC8) against six dependent variables are presented in **Table 4.56** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.56: Coefficients for LC8

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.57**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.57: Collinearity Diagnostics for LC8

Model	Dimension	Eigen value	Condition Index	Variance Proportions (Constant)	LL	TW	MR	SR	WE	AC
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.14 Safe Activities and Conditions (LC9)

Results of coefficients of safe activities and conditions (LC9) against six dependent variables are presented in **Table 4.58** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.58: Coefficients for LC9

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.192	0.173		6.908	0.00		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.59**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.59: Collinearity Diagnostics for LC9

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions**						
				(Constant)	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.6	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.15 Safety Concerns (LC10)

Results of coefficients of safety concerns (LC10) against six dependent variables are presented in **Table 4.60** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.60: Coefficients for LC10

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.61**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

TABLE 4.61: Collinearity Diagnostics for LC10

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions (Constant)**	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.16 Safety Policy (LC11)

Results of coefficients of safety policy (LC11) against six dependent variables are presented in **Table 4.62** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.62: Coefficients for LC11

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.63	1.588

Collinearity diagnostics (**Table 4.63**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

Table 4.63: Collinearity Diagnostics for LC11

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions**						
				(Constant)	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.9.17 Safety Standards (LC12)

Results of coefficients of safety standards (LC12) against six dependent variables are presented in **Table 4.64** in which this study concerns collinearity statistics values (Tolerance and VIF). It can be noted that Tolerance values are much greater than 0.2 and VIF values are much less than 5, indicating no collinearity.

Table 4.64: Coefficients for LC12

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.192	0.173		6.908	0.000		
	LL	0.167	0.048	0.181	3.475	0.001	0.754	1.326
	TW	0.059	0.046	0.067	1.27	0.205	0.745	1.342
	MR	-0.088	0.046	-0.105	-1.929	0.054	0.685	1.459
	SR	-0.037	0.046	-0.043	-0.798	0.425	0.701	1.427
	WE	0.103	0.041	0.124	2.472	0.014	0.808	1.238
	AC	0.049	0.05	0.056	0.988	0.324	0.630	1.588

Collinearity diagnostics (**Table 4.65**) presents that none of the Eigen values among variables is close to zero and condition index values are less than 15. Testing all four values among the variables, it is noted that no collinearity has been found among the variables.

TABLE 4.65: Collinearity Diagnostics for LC12

Model	**Dimension**	**Eigen value**	**Condition Index**	**Variance Proportions (Constant)**	**LL**	**TW**	**MR**	**SR**	**WE**	**AC**
1	1	6.481	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.121	7.322	0.00	0.02	0.17	0.00	0.05	0.74	0.01
	3	0.105	7.851	0.01	0.08	0.02	0.60	0.11	0.06	0.08
	4	0.096	8.212	0.01	0.54	0.09	0.03	0.23	0.06	0.07
	5	0.079	9.042	0.06	0.02	0.48	0.01	0.60	0.03	0.02
	6	0.061	10.275	0.00	0.23	0.02	0.36	0.00	0.02	0.79
	7	0.056	10.774	0.92	0.11	0.22	0.00	0.00	0.08	0.02

4.2.10 Correlation Analysis

The result of correlation analysis determines the degree of existence or non-existence of an inter-correlation between variables [225]. Correlation analysis is indicated by a value ranging from -1 to +1, and any zero value in between shows no correlation. Here, a positive correlation value is indicated by 1, referring to the movement of variables in the same direction where an increase in one variable causes an increase in the other variable. Similarly, the value of -1 shows a negative correlation, signifying an inverse relationship of variables where an increase in the value of one variable causes a decrease in the value of another variable. While no correlation effect is specified as any increase or decrease in one variable is unable to bring any change in another variable [226].

There are six main variables explored in this research study; the variable of lean culture has 12 dimensions. **Tables 4.66** presents the results of the correlation analysis. This table also includes selected demographic variables as demographic variables are imperative and have the potential to influence results and produce useful insights about the theoretical model [227]. Thus, demographic variables enable researchers to make conclusions about a certain group of individuals and their behavioural patterns. **Table 4.66** indicated that all of the correlations were positive and significant except some demographic variables. LC was positively and substantially associated with LL ($r = .213^{**}$, $p = .000$), TW ($r = .259^{**}$, $p = .000$), MR ($r = .324^{**}$, $p = .000$), SR ($r = .407^{**}$, $p = .000$), WE ($r = .296^{**}$, $p = .000$), AC ($r = .343^{**}$, $p = .000$) and all its twelve dimensions.

4.2.11 Effect Size Analysis

Effect size analysis has been done and the results are displayed in **Table 4.67**. The larger the effect size, the stronger the link between two variables. The figures 0.10, 0.25, and 0.40 represent small, medium, and large effect sizes, respectively. When $f = 0$, it indicates that all of the population's means are equal. Cohen's f value will get indefinitely larger as the ways become farther distant from one another [197].

Table 4.66: Correlation Analysis (n=462)

	BD1	BD2	BD3	BD4	LC	LL	TW	MR	SR	WE	AC	LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC10	LC11	LC12
BD1	1.000																						
BD2	.340**	1.000																					
BD3	.230**	.255**	1.000																				
BD4	-.108*	-.051	-.083	1.000																			
LC	.113*	.102*	-.048	-.054	1.000																		
LL	.204**	.154**	.159**	-.022	.213**	1.000																	
TW	.105*	.132**	.090	.003	.259**	.302**	1.000																
MR	.011	.006	.041	-.043	.324**	.282**	.379**	1.000															
SR	.087	.100*	.051	.054	.407**	.376**	.416**	.388**	1.000														
WE	.162**	-.050	.069	.008	.296**	.273**	.215**	.320**	.319**	1.000													
AC	.102*	.111*	.104*	-.074	.343**	.408**	.351**	.502**	.377**	.384**	1.000												
LC1	.230**	.147**	.154**	-.049	.242**	.919**	.299**	.304**	.344**	.280**	.415**	1.000											
LC2	.204**	.197**	.023	-.018	.213**	.411**	.269**	.360**	.327**	.319**	.313**	.469**	1.000										
LC3	.171**	.312**	.094*	-.071	.139**	.205**	.167**	.308**	.194**	.105**	.181**	.260**	.510**	1.000									
LC4	.126**	.342**	.103*	-.072	.240**	.241**	.380**	.200**	.259**	.158**	.266**	.320**	.486**	.480**	1.000								
LC5	.156**	.257**	.158**	-.037	.201**	.155**	.305**	.220**	.301**	.195**	.216**	.202**	.354**	.401**	.603**	1.000							
LC6	.249**	.299**	.125**	-.068	.181**	.154**	.352**	.129**	.304**	.222**	.187**	.168**	.415**	.356**	.480**	.555**	1.000						
LC7	.208**	.238**	.087	-.029	.221**	.288**	.350**	.322**	.387**	.222**	.347**	.241**	.395**	.394**	.426**	.426**	.557**	1.000					
LC8	.212**	.223**	.109*	-.048	.173**	.302**	.267**	.356**	.214**	.311**	.403**	.296**	.417**	.397**	.435**	.325**	.429**	.579**	1.000				
LC9	.171**	.106*	.062	-.009	.230**	.277**	.308**	.428**	.300**	.287**	.404**	.286**	.344**	.338**	.361**	.337**	.330**	.489**	.559**	1.000			
LC10	.145**	.092*	.056	-.005	.269**	.277**	.293**	.384**	.229**	.253**	.303**	.283**	.347**	.332**	.261**	.316**	.386**	.390**	.527**	.497**	1.000		
LC11	.099*	.018	.048	-.070	.307**	.304**	.442**	.392**	.350**	.356**	.332**	.352**	.397**	.351**	.385**	.284**	.311**	.281**	.392**	.466**	.543**	1.000	
LC12	.125**	.094*	.093*	-.024	.235**	.226**	.363**	.268**	.212**	.361**	.305**	.277**	.469**	.355**	.351**	.313**	.328**	.297**	.438**	.392**	.546**	.596**	1.000

Note: ** $p < 0.01$, *$p < 0.05$

Results in Table 4.67 indicated that Cohen's f value for MR and LC6 was 0.190. Cohen's f value for SR and LC8 was 0.217. Cohen's f value for WE and LC3 was 0.190, and WE and LC4 was 0.220. Cohen's f value for AC and LC3 was 0.248, WE and LC5 was 0.241, and WE and LC6 was 0.244. All these values were between 0.1 and 0.25 which means they had small effect sizes. Small effect sizes indicate a weak relationship between the two variables. Cohen's f value for LL and LC1 was 2.499, LL and LC2 was 0.563, LL and LC3 was 0.407, LL and LC8 was 0.435, and LL and LC10 was 0.462. Cohen's f value for TW and LC4 was 0.410, TW and LC6 was 0.418, TW and LC11 was 0.498, and TW and LC12 was 0.418. Cohen's f value for MR and LC2 was 0.413, MR and LC8 was 0.417, MR and LC9 was 0.487, MR and LC10 was 0.420, and MR and LC11 was 0.435. Cohen's f value for SR and LC was 0.508, and SR and LC7 was 0.425. Cohen's f value for WE and LC11 was 0.405, and WE and LC12 was 0.428. Cohen's f value for AC and LC1 was 0.456, AC and LC7 was 0.420, AC and LC8 was 0.435, and AC and LC9 was 0.475. All these values were greater than 0.4 which means they had large effect size. A large effect size indicates a strong relationship. Cohen's f values for the remaining variables were between 0.25 and 0.4 which means they had medium effect size. Medium effect size indicates an intermediate relationship between the variables. To be concluded, LL had an intermediate relationship with LC, LC4, LC5, LC6, LC7, LC9, LC11 and LC12. LL had a strong relationship with LC1, LC2, LC3, LC8 and LC10. TW had an intermediate relationship with LC, LC1, LC2, LC3, LC5, LC7, LC8, LC9 and LC10. TW had a strong relationship with LC4, LC6, LC11 and LC12. MR had a weak relationship with LC6.

MR had an intermediate relationship with LC, LC1, LC3, LC4, LC5, LC7 and LC12. SR had an intermediate relationship with LC, LC1, LC2, LC3, LC4, LC5, LC6, LC9, LC10, LC11 and LC12. SR had a strong relationship with LC and LC7. WE had a weak relationship with LC3 and LC4. WE had an intermediate relationship with LC, LC1, LC2, LC5, LC6, LC7, LC8, LC9 and LC10. WE had a strong relationship with LC11 and LC12. AC had a weak relationship with LC3, LC5 and LC6. AC had an intermediate relationship with LC, LC2, LC4, LC10, LC11 and LC12. AC had a strong relationship with LC1, LC7, LC8 and LC9.

Table 4.67: Summary of Effect Size Analysis

	LL				TW				MR				SR				WE				AC			
	DF, Error	F	Sig	η^2	DF, Error	F	Sig	η^2	DF, Error	F	Sig	η^2	DF, Error	F	Sig	η^2	DF, Error	F	Sig	η^2	DF, Error	F	Sig	η^2
LC	4,457	.257	.000	.062	4,457	.318	.000	.092	4,457	.380	.000	.126	4,457	.508	.000	.205	4,457	.366	.000	.118	4,457	.387	.000	.130
LC1	4,457	2.499	.000	.862	4,457	.369	.000	.120	4,457	.339	.000	.103	4,457	.398	.000	.137	4,457	.309	.000	.087	4,457	.456	.000	.172
LC2	4,457	.563	.000	.241	4,457	.335	.000	.101	4,457	.413	.000	.146	4,457	.373	.000	.122	4,457	.357	.000	.113	4,457	.324	.000	.095
LC3	4,457	.407	.000	.142	4,457	.307	.000	.086	4,457	.360	.000	.115	4,457	.272	.000	.069	4,457	.190	.003	.035	4,457	.248	.000	.058
LC4	4,457	.314	.000	.090	4,457	.410	.000	.144	4,457	.259	.000	.063	4,457	.281	.000	.073	4,457	.220	.000	.046	4,457	.311	.000	.088
LC5	4,457	.301	.000	.083	4,457	.335	.000	.101	4,457	.355	.000	.112	4,457	.328	.000	.097	4,457	.272	.000	.069	4,457	.241	.000	.055
LC6	4,457	.257	.000	.062	4,457	.418	.000	.149	4,457	.190	.002	.035	4,457	.341	.000	.104	4,457	.255	.000	.061	4,457	.244	.000	.056
LC7	4,457	.339	.000	.103	4,457	.392	.000	.133	4,457	.352	.000	.110	4,457	.425	.000	.153	4,457	.328	.000	.097	4,457	.420	.000	.150
LC8	4,457	.435	.000	.159	4,457	.366	.000	.118	4,457	.417	.000	.148	4,457	.217	.000	.045	4,457	.346	.000	.107	4,457	.435	.000	.159
LC9	4,457	.398	.000	.137	4,457	.350	.000	.109	4,457	.487	.000	.192	4,457	.326	.000	.096	4,457	.303	.000	.084	4,457	.475	.000	.184
LC10	4,457	.462	.000	.176	4,457	.381	.000	.127	4,457	.420	.000	.150	4,457	.295	.000	.080	4,457	.375	.000	.123	4,457	.357	.000	.113
LC11	4,457	.344	.000	.106	4,457	.498	.000	.199	4,457	.435	.000	.159	4,457	.390	.000	.132	4,457	.405	.000	.141	4,457	.366	.000	.118
LC12	4,457	.303	.000	.084	4,457	.418	.000	.149	4,457	.309	.000	.087	4,457	.297	.000	.081	4,457	.428	.000	.155	4,457	.328	.000	.097

4.2.12 Direct Relationship of Lean Culture with Outcome Variables

For more than a century, scholars have been examining the relationship between predictor and criterion variables through linear regression analysis [228]. Advancement in all the research fields has also corresponded to significant changes in the statistical analysis tools such as Structural Equation Modelling (SEM) through AMOS. This study uses the SEM technique to examine the association of predictor and criterion variables. The predictor variable is composed of a composite form of lean culture and its dimensions. Using the composite and dimensional form of lean culture is in line with the earlier studies [229-231]. While criterion variables in this study are lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement. Examination and outcomes of the direct relationship are shown in **Table 4.68** and **Figure 4.9** (a, b, c, d, e, f) as given below along with appropriate control variables in each model. The critical ratio (C.R.) value is obtained by this ratio.

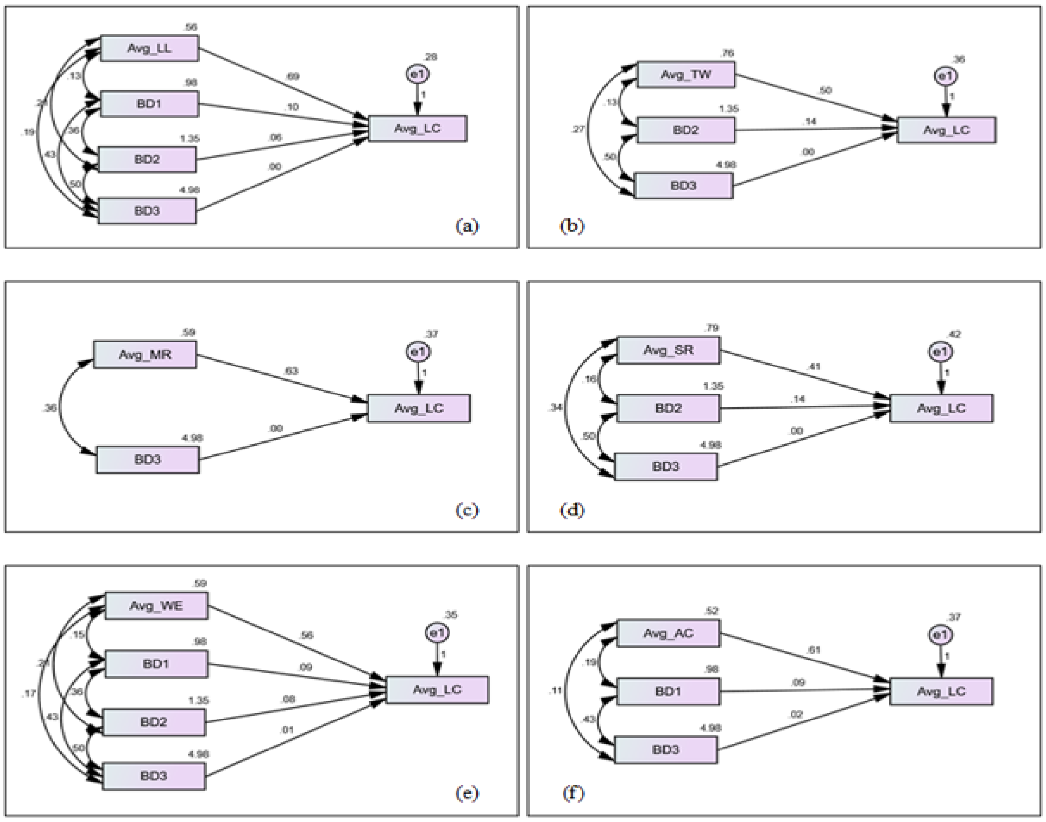


FIGURE 4.9: Direct Relationship of Lean culture with Outcome Variables

$$CR = \beta\ /SE$$

Where; β is the estimated value. CR value must be greater than ± 1.96 to achieve a stronger relationship between the variables [232]. It can be seen in **Table 4.68** that CR values for all relationships are much greater than the threshold value, therefore the significance (P value) of these relationships is *** which means the p-value is <.001.

TABLE 4.68: Regression Weights of Structural Path

Structural Path	**Estimate (β)**	**S.E.**	**C.R.**	**P**
LC ← LL	0.688	0.034	20.205	***
LC ← TW	0.504	0.033	15.502	***
LC ← MR	0.628	0.038	16.671	***
LC ← SR	0.414	0.035	11.929	***
LC ← WE	0.565	0.037	15.16	***
LC ← AC	0.607	0.041	14.868	***

4.2.13 Relation of Dimensions of Lean Culture with Outcome Variables

The diagram for dimensions of lean culture with outcome variables has been created using Amos.

The results for this diagram have been presented in **Table 4.69**. A hypothesis is accepted for the two variables if they are positively and significantly associated with each other. If the estimate is positive and CR value is greater than 1.96, the two variables are positively associated with each other. If p-value is less than 0.05, they are significantly associated with each other. If p-value is less than 0.05, it is significant and represented by *. If p-vale is less than 0.01, it is more significant and represented by **. If p-value is less than 0.001, it is much more significant and represented by***. Table 4.69 indicated that estimates of LL with LC2, LC6, LC8, LC11 and LC12 were 0.097, 0.123, 0.084, 0.112 and 0.110 respectively. All these estimates are positive. CR values of LL with LC2, LC6, LC8, LC11 and LC12 were 3.212, 4.187, 2.742, 3.605 and 3.343 respectively. CR values for all these variables are greater than 1.96.

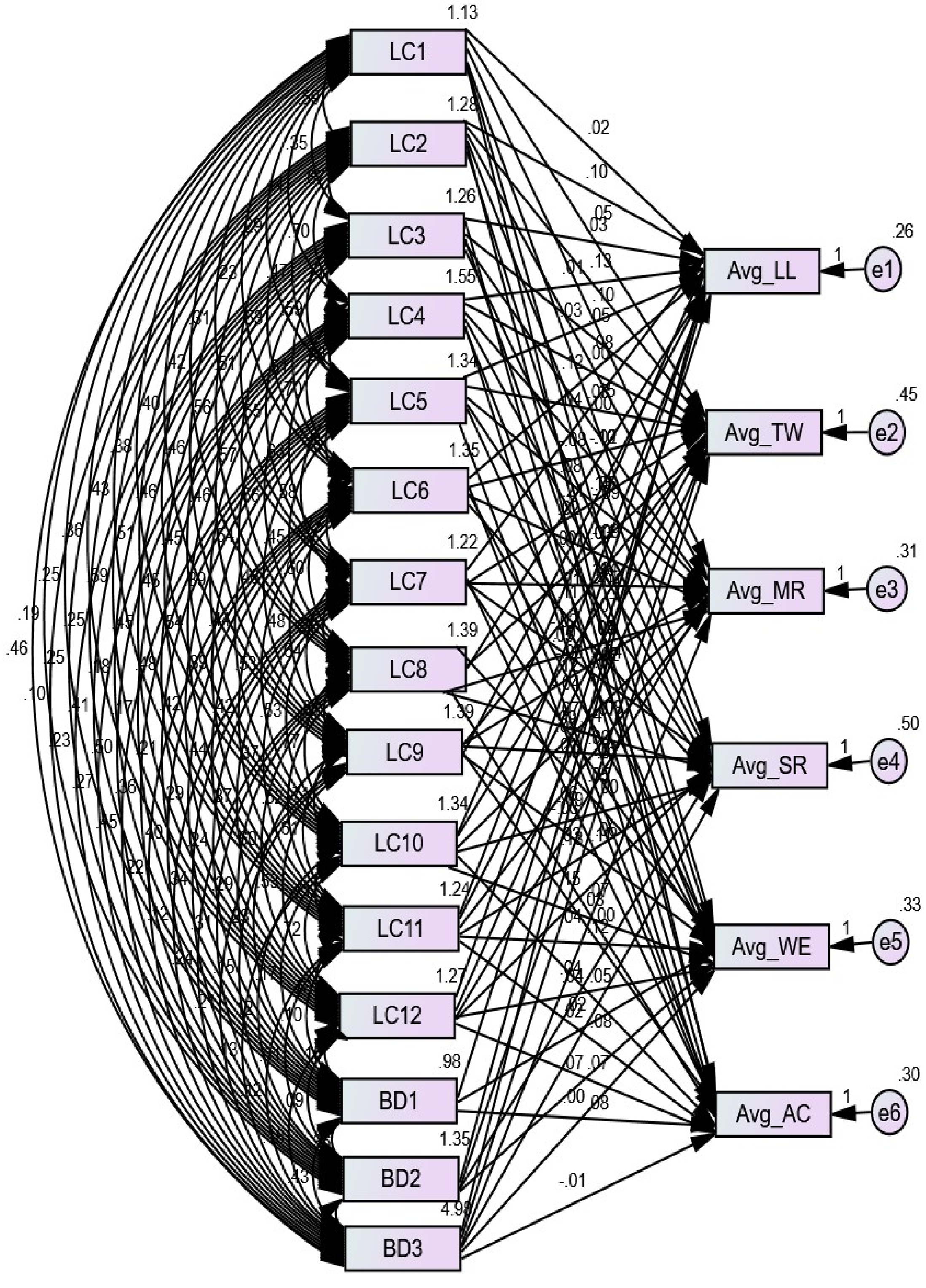


FIGURE 4.10: Dimensions of Lean Culture with Outcome Variables

The p-values of LL with LC2, LC6, LC8, LC11 and LC12 were 0.001, ***, 0.006, *** and *** respectively. The p-values for all these variables are less than 0.05. All these values of estimates, CR and significance (p-value) values indicated that LL was positively and significantly associated with these dimensions. Estimates of TW with LC2, LC7, LC11 and LC12 were 0.126, 0.214, 0.118 and 0.091. All these estimates are positive. CR values of TW with LC2, LC7, LC11 and LC12 were 3.203, 5.246, 2.907 and 2.313. All these CR values are greater than 1.96. The p-values of TW with LC2, LC7, LC11 and LC12 were 0.001, ***, 0.004 and 0.021. The p-values for all these variables are less than 0.05. All these values of estimates, CR and significance (p-value) values indicated that TW was positively and significantly associated with LC2, LC7, LC11 and LC12. Estimates of MR with LC1, LC2, LC5, LC7 and LC11 were 0.103, 0.081, 0.125, 0.156 and 0.189 respectively. All these estimates were positive. CR values for MR with LC1, LC2, LC5, LC7 and LC11 were 3.440, 2.489, 3.970, 4.609 and 5.667 respectively. CR values for all these variables were greater than 1.96. The p-values for MR with LC1, LC2, LC5, LC7 and LC11 were ***, 0.013, ***, *** and *** respectively. The p-values for all these variables were less than 0.05. All these values of estimates, CR and significance (p-value) values indicated that MR was positively and significantly associated with LC1, LC2, LC5, LC7 and LC11. The estimates of SR with LC1, LC2, LC5, LC8, LC11 and LC12 were 0.150, 0.102, 0.230, 0.138, 0.125, 0.151 respectively. Estimates for all these variables were positive. CR values for SR with LC1, LC2, LC5, LC8, LC11 and LC12 were 3.938, 2.477, 5.737, 3.320, 2.936 and 3.663 respectively. CR values for all these variables were greater than 1.96.

The p-values for SR with LC1, LC2, LC5, LC8, LC11 and LC12 were ***, 0.013, ***, ***, 0.003 and *** respectively. The p-values for all these variables were less than 0.05. All these values of estimates, CR and significance (p-value) values indicated that SR was positively and significantly associated with LC1, LC2, LC5, LC8, LC11 and LC12. Estimates of WE with LC2, LC4, LC9 and LC11 were 0.111, 0.092, 0.114 and 0.123 respectively. Estimates for all these variables were positive. CR values for WE with LC2, LC4, LC9 and LC11 were 3.276, 2.872, 3.701 and 3.528 respectively. CR values for all these variables were greater than 1.96. The p-values for WE with LC2, LC4, LC9 and LC11 were 0.004, 0.004, *** and *** respectively. The p-values for all these variables were less than 0.05. All these values of estimates, CR and significance (p-value) values indicated that WE was positively and significantly associated with LC2, LC4, LC9 and LC11.

TABLE 4.69: Results of Relationships between Dimensions of Lean Culture and Outcomes

	LL				TW				MR				SR				WE				AC			
	Estimate	S.E.	C.R.	P	Estimate	S.E.	C.R.	P	Estimate	S.E.	C.R.	P	Estimate	S.E.	C.R.	P	Estimate	S.E.	C.R.	P	Estimate	S.E.	C.R.	P
BD1	-.036	.027	-1.333	.183	-	-	-	-	-	-	-	-	-	-	-	-	.020	.030	.672	.502	.079	.028	2.837	.005
BD2	.040	.024	1.660	.097	-.028	.031	-.904	.366	-	-	-	-	.040	.032	1.226	.220	.075	.027	2.767	.006	-	-	-	-
BD3	.012	.011	1.025	.306	.032	.015	2.189	.029	.041	.012	3.384	***	.024	.015	1.535	.125	.003	.013	.210	.833	-.011	.012	-.871	.384
LC1	.016	.028	.573	.567	.054	.036	1.486	.137	.103	.030	3.440	***	.150	.038	3.938	***	.056	.031	1.791	.073	.140	.030	4.684	***
LC2	.097	.030	3.212	.001	.126	.039	3.203	.001	.081	.033	2.489	.013	.102	.041	2.477	.013	.111	.034	3.276	.001	.071	.032	2.195	.028
LC3	.035	.028	1.223	.221	.053	.037	1.431	.152	.002	.030	.064	.949	-.093	.039	-2.386	.017	-.041	.032	-1.302	.193	-.038	.030	-1.272	.203
LC4	.015	.028	.526	.599	.000	.037	.003	.998	-.019	.030	-.638	.523	-.087	.039	-2.250	.024	.092	.032	2.872	.004	.066	.030	2.214	.027
LC5	.027	.029	.940	.347	.034	.038	.884	.376	.125	.032	3.970	***	.230	.040	5.737	***	.018	.033	.564	.573	-.008	.031	-.262	.793
LC6	.123	.029	4.187	***	-.076	.038	-1.986	.047	.028	.031	.891	.373	-.001	.040	-.035	.972	-.084	.033	-2.540	.011	.000	.031	-.001	.999
LC7	.042	.031	1.340	.180	.214	.041	5.246	***	.156	.034	4.609	***	-.024	.043	-.549	.583	.057	.035	1.622	.105	.058	.033	1.720	.085
LC8	.084	.030	2.742	.006	.072	.040	1.828	.067	.054	.033	1.646	.100	.138	.042	3.320	***	.052	.034	1.512	.130	.071	.033	2.188	.029
LC9	.021	.027	.748	.455	.014	.036	.387	.699	-.064	.030	-2.156	.031	-.001	.038	-.030	.976	.114	.031	3.701	***	-.003	.029	-.115	.908
LC10	.002	.030	.064	.949	-.017	.039	-.448	.655	-.075	.032	-2.328	.020	-.089	.041	-2.186	.029	.031	.033	.929	.353	.053	.032	1.677	.093
LC11	.112	.031	3.605	***	.118	.041	2.907	.004	.189	.033	5.667	***	.125	.043	2.936	.003	.123	.035	3.528	***	.080	.033	2.414	.016
LC12	.100	.030	3.343	***	.091	.039	2.313	.021	.056	.033	1.711	.087	.151	.041	3.663	***	.036	.034	1.068	.285	.066	.032	2.040	.041

The estimates of AC with LC1, LC2, LC4, LC8, LC11 and LC12 were 0.140, 0.071, 0.066, 0.071, 0.080 and 0.066 respectively. Estimates for all these variables were positive. CR values for AC with LC1, LC2, LC4, LC8, LC11 and LC12 were 4.684, 2.195, 2.214, 2.188, 2.414 and 2.040 respectively. CR values for all these variables were greater than1.96. The p-values for AC with LC1, LC2, LC4, LC8, LC11 and LC12 were ***, 0.028, 0.027, 0.029, 0.016 and 0.041 respectively. The p-values for all these variables were less than 1.96. All these values of estimates, CR and significance (p-value) values indicated that AC was positively and significantly associated with LC1, LC2, LC4, LC8, LC11 and LC12. To be concluded, LL was positively and significantly associated with 5 dimensions out of 12. TW, MR, SR, WE and AC were positively and significantly associated with 4, 5, 6, 4 and 6 dimensions respectively.

4.3 Hypothesis Testing

This section presents the results of hypothesis 1 to hypothesis 12, which are based on the relationship between dimensions of lean culture and outcome variables, i.e., lean leadership, teamwork, management role, social responsibility, working environment, and auditing and continuous improvement.

H_1: Lean culture is positively and significantly associated with lean leadership.

Estimates of the structural paths are presented in **Table 4.68** and **Figure 4.9** (a). The control variables for this model were educational qualification (BD1), professional experience (BD2) and firm category (BD3); and were controlled in the analysis to avoid their influence on the relationship. Result shows that lean culture is positively and significantly associated with lean leadership (β = .688, C.R. = 20.205, P = ***). The effect size for this relationship is F (4, 457) = 7.614, P = .000, η^2 = .062 indicating a high effect size (**Table 4.67**). Thus, hypothesis H_1 was accepted.

H_2: The dimensions of lean culture, i.e. (a) safe working environment, (b) safety officer and supervisor, (c) reduced health and safety hazards,

(d) safety training, (e) safety commitment, (f) safety incentives, (g) safety inspection and monitoring, (h) safety awareness, (i) safe activities and conditions, (j) safety concerns, (k) safety policy and (l) safety standards are positively and significantly associated with lean leadership.

H_{2a}: Safe working environment (LC1) is positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe working environment (LC1) is positively and insignificantly associated with lean leadership (β = .016, C.R. = .573, P = .567). The effect size for this relationship is F (4, 457) = 710.979, P = .000, η^2 = .862 indicating a high effect size **Table 4.67**). Hence, the hypothesis H_{2a} was rejected.

H_{2b}: Safety officer and supervisor (LC2) are positively and significantly associated with lean leadership.

Table 4.69 and **Figure 4.10** present that the dimension of lean culture, safety officer and supervisor (LC2) is positively and significantly associated with lean leadership (β = .097, C.R. = 3.212, P = .001). The effect size for this relationship is F (4, 457) = 36.218, P = .000, η^2 = .241 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2b} was accepted.

H_{2c}: Reduced health and safety hazards are positively and significantly associated with lean leadership.

Table 4.69 and **Figure 4.10** present that the dimension of lean culture, reduced health and safety hazards (LC3) is positively and insignificantly associated with lean leadership (β = .035, C.R. = 1.223, P = .221). The effect size for this relationship is F (4, 457) = 18.942, P = .000, η^2 = .142 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2c} was rejected.

H_{2d}: Safety training is positively and significantly associated with lean leadership.

Table 4.69 and **Figure 4.10** present that the dimension of lean culture, safety training (LC4) is positively and insignificantly associated with lean leadership (β

= .015, C.R. = .526, P = .599). The effect size for this relationship is F (4, 457) = 11.248, P = .000, η^2 = .090 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2d} was rejected.

H_{2e}: Safety commitment is positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety equipment (LC5) is positively and insignificantly associated with lean leadership (β = .027, C.R. = .940, P = .347). The effect size for this relationship is F (4, 457) = 10.371, P = .000, η^2 = .083 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2e} was rejected.

H_{2f}: Safety incentives are positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety incentives (LC6) is positively and significantly associated with lean leadership (β = .123, C.R. = 4.187, P = ***). The effect size for this relationship is F (4, 457) = 7.517, P = .000, η^2 = .062 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2f} was accepted.

H_{2g}: Safety inspection and monitoring are positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety inspection and monitoring (LC7) is positively and insignificantly associated with lean leadership (β = .042, C.R. = 1.340, P = .180). The effect size for this relationship is F (4, 457) = 13.182, P = .000, η^2 = .103 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2g} was rejected.

H_{2h}: Safety awareness is positively and significantly associated with lean leadership.

Table 4.69 and **Figure 4.10** present that the dimension of lean culture, safety awareness (LC8) is positively and significantly associated with lean leadership (β = .084, C.R. = 2.742, P = .006). The effect size for this relationship is F (4, 457) = 21.527, P = .000, η^2 = .159 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2h} was accepted.

H_{2i}: Safe activities and conditions are positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe activities and conditions (LC9) is positively and insignificantly associated with lean leadership (β = .021, C.R. = .748, P = .455). The effect size for this relationship is F (4, 457) = 18.203, P = .000, η^2 = .137 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2i} was rejected.

H_{2j}: Safety concerns are positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety concerns (LC10) is positively and insignificantly associated with lean leadership (β = .002, C.R. = .064, P = .949). The effect size for this relationship is F (4, 457) = 24.445, P = .000, η^2 = .176 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2j} was rejected.

H_{2k}: Safety policy is positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety policy (LC11) is positively and significantly associated with lean leadership (β = .112, C.R. = 3.605, P = ***). The effect size for this relationship is F (4, 457) = 13.590, P = .000, η^2 = .106 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2k} was accepted.

H_{2l}: Safety standards are positively and significantly associated with lean leadership.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety standards (LC12) is positively and significantly associated with lean leadership (β = .100, C.R. = 3.343, P = ***). The effect size for this relationship is F (4, 457) = 10.437, P = .000, η^2 = .084 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{2l} was accepted.

Thus, the hypotheses (H_1, H_{2b}, H_{2f}, H_{2h}, H_{2k}, H_{2l}) were accepted, and hypotheses (H_{2a}, H_{2c}, H_{2d}, H_{2e}, H_{2g}, H_{2i}, H_{2j}) were rejected.

H_3: Lean culture is positively and significantly associated with teamwork.

Estimates of the structural paths are presented in Table 4.68 and Figure 4.9 (b). The control variables for this model were professional experience (BD2) and firm category (BD3); and were controlled in the analysis to avoid their influence on the relationship. Result shows that lean culture is positively and significantly associated with teamwork (β = .504, C.R. = 15.502, P = ***). The effect size for this relationship is F (4, 457) = 11.531, P = .000, η^2 = .092 indicating a high effect size (**Table 4.67**). Thus, hypothesis H_3 was accepted.

H_4: The dimensions of lean culture, i.e. (a) safe working environment, (b) safety officer and supervisor, (c) reduced health and safety hazards, (d) safety training, (e) safety commitment, (f) safety incentives, (g) safety inspection and monitoring, (h) safety awareness, (i) safe activities and conditions, (j) safety concerns, (k) safety policy and (l) safety standards are positively and significantly associated with teamwork.

H_{4a}: Safe working environment is positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe working environment (LC1) is positively and insignificantly associated with teamwork (β = .054, C.R. = 1.486, P = .137). The effect size for this relationship is F (4, 457) = 15.651, P = .000, η^2 = .120 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4a} was rejected.

H_{4b}: Safety officer and supervisor are positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety officer and supervisor (LC2) is positively and significantly associated with teamwork (β= .126, C.R. = 3.203, P = .001). The effect size for this relationship is F (4, 457) = 12.788, P = .000, η^2 = .101 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4b} was accepted.

H_{4c}: Reduced health and safety hazards are positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, reduced health and safety hazards (LC3) is positively and insignificantly associated with teamwork (β = .053, C.R. = 1.431, P = .152). The effect size for this relationship is F (4, 457) = 10.688, P = .000, η^2 = .086 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4c} was rejected.

H_{4d6}: Safety training is positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety training (LC4) is positively and insignificantly associated with teamwork (β = .000, C.R. = .003, P = .998). The effect size for this relationship is F (4, 457) = 19.213, P = .000, η^2 = .144 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4d} was rejected.

H_{4e}: Safety commitment is positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety equipment (LC5) is positively and insignificantly associated with teamwork (β = .034, C.R. = .884, P = .376). The effect size for this relationship is F (4, 457) = 12.864, P = .000, η^2 = .101 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4e} was rejected.

H_{4f}: Safety incentives are positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety incentives (LC6) is negatively and significantly associated with teamwork (β = -.076, C.R. = -1.986, P = .047). The effect size for this relationship is F (4, 457) = 20.032, P = .000, η^2 = .149 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4f} was rejected.

H_{4g}: Safety inspection and monitoring are positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety inspection and monitoring (LC7) is positively and significantly associated with teamwork (β = .214, C.R. = 5.246, P = ***). The effect size for this relationship is F (4, 457) = 17.481, P = .000, η^2 = .133 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4g} was accepted.

H_{4h}: Safety awareness is positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety awareness (LC8) is positively and insignificantly associated with teamwork (β = .072, C.R. = 1.828, P = .067). The effect size for this relationship is F (4, 457) = 15.340, P = .000, η^2 = .118 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4h} was rejected.

H_{4i}: Safe activities and conditions are positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe activities and conditions (LC9) is positively and insignificantly associated with teamwork (β = .014, C.R. = .387, P = .699). The effect size for this relationship is F (4, 457) = 13.975, P = .000, η^2 = .109 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4i} was rejected.

H_{4j}: Safety concerns are positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety concerns (LC10) is negatively and insignificantly associated with teamwork (β= -.017, C.R. = -.448, P = .655). The effect size for this relationship is F (4, 457) = 16.648, P = .000, η^2 = .127 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4j} was rejected.

H_{4k}: Safety policy is positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety policy (LC11) is positively and significantly associated with teamwork (β = .118, C.R. = 2.907, P = .004). The effect size for this relationship is F (4, 457) = 28.364, P = .000, η^2 = .199 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4k} was accepted.

H_{4l}: Safety standards are positively and significantly associated with teamwork.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety standards (LC12) is positively and significantly associated with teamwork (β = .091, C.R. = 2.313, P = .021). The effect size for this relationship is F (4, 457) = 19.973, P = .000, η^2 = .149 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{4l} was accepted.

Thus, the hypotheses (H_3, H_{4b}, H_{4g}, H_{4k}, H_{4l}) were accepted, and hypotheses (H_{4a}, H_{4c}, H_{4d}, H_{4e}, H_{4f}, H_{4h}, H_{4i}, H_{4j}) were rejected.

H_5: Lean culture is positively and significantly associated with management role.

Estimates of the structural paths are presented in Table 4.68 and Figure 4.9 (c). The control variable for this model was firm category (BD3); and was controlled in the analysis to avoid its influence on the relationship. Result shows that lean culture is positively and significantly associated with management role (β = .628, C.R. = 16.671, P = ***). The effect size for this relationship is F (4, 457) = 16.519, P = .000, η^2 = .126 indicating a high effect size (**Table 4.67**). Thus, hypothesis H_5 was accepted.

H_6: The dimensions of lean culture, i.e. (a) safe working environment, (b) safety officer and supervisor, (c) reduced health and safety hazards, (d) safety training, (e) safety commitment, (f) safety incentives, (g) safety inspection and monitoring, (h) safety awareness, (i) safe activities and conditions, (j) safety concerns, (k) safety policy and (l) safety standards are positively and significantly associated with management role.

H_{6a}: Safe working environment is positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe working environment (LC1) is positively and significantly associated with management role (β = .103, C.R. = 3.440, P = ***). The effect size for this relationship is F

(4, 457) = 13.153, P = .000, η^2 = .103 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6a} was accepted.

H_{6b}: Safety officer and supervisor are positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety officer and supervisor (LC2) is positively and significantly associated with management role (β = .081, C.R. = 2.489, P = .013). The effect size for this relationship is F (4, 457) = 19.569, P = .000, η^2 = .146 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6b} was accepted.

H_{6c}: Reduced health and safety hazards are positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, reduced health and safety hazards (LC3) is positively and insignificantly associated with management role (β = .002, C.R. = .064, P = .949). The effect size for this relationship is F (4, 457) = 14.857, P = .000, η^2 = .115 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6c} was rejected.

H_{6d}: Safety training is positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety training (LC4) is negatively and insignificantly associated with management role (β = -.019, C.R. = -.638, P = .523). The effect size for this relationship is F (4, 457) = 7.619, P = .000, η^2 = .063 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6d} was rejected.

H_{6e}: Safety commitment is positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety equipment (LC5) is positively and significantly associated with management role (β = .125, C.R. = 3.970, P = ***). The effect size for this relationship is F (4, 457) = 14.377, P = .000, η^2 = .112 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6e} was accepted.

H_{6f}: Safety incentives are positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety incentives (LC6) is positively and insignificantly associated with management role (β = .028, C.R. = .891, P = .373). The effect size for this relationship is F (4, 457) = 4.184, P = .002, η^2 = .035 indicating a medium effect size (**Table 4.67**). Hence, the hypothesis H_{6f} was rejected.

H_{6g}: Safety inspection and monitoring are positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety inspection and monitoring (LC7) is positively and significantly associated with management role (β = .156, C.R. = 4.609, P = ***). The effect size for this relationship is F (4, 457) = 14.155, P = .000, η^2 = .110 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6g} was accepted.

H_{6h}: Safety awareness is positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety awareness (LC8) is positively and insignificantly associated with management role (β = .054, C.R. = 1.646, P = .100). The effect size for this relationship is F (4, 457) = 19.851, P = .000, η^2 = .148 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6h} was rejected.

H_{6i}: Safe activities and conditions are positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe activities and conditions (LC9) is negatively and significantly associated with management role (β = -.064, C.R. = -2.156, P = .031). The effect size for this relationship is F (4, 457) = 27.185, P = .000, η^2 = .192 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6i} was rejected.

H_{6j}: Safety concerns are positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety concerns (LC10) is negatively and significantly associated with management role (β = -.075, C.R. = -2.328, P = .020). The effect size for this relationship is F (4, 457) = 20.131, P = .000, η^2 = .150 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6j} was rejected.

H_{6k}: Safety policy is positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety policy (LC11) is positively and significantly associated with management role (β = .189, C.R. = 5.667, P = ***). The effect size for this relationship is F (4, 457) = 21.604, P = .000, η^2 = .159 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6k} was accepted.

H_{6l}: Safety standards are positively and significantly associated with management role.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety standards (LC12) is positively and insignificantly associated with management role (β = .056, C.R. = 1.711, P = .087). The effect size for this relationship is F (4, 457) = 10.865, P = .000, η^2 = .087 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{6l} was rejected.

Thus, the hypotheses (H_5, H_{6a}, H_{6b}, H_{6e}, H_{6g}, H_{6k}) were accepted, and hypotheses (H_{6c}, H_{6d}, H_{6f}, H_{6h}, H_{6i}, H_{6j}, H_{6l}) were rejected.

H_7: Lean culture is positively and significantly associated with social responsibility.

Estimates of the structural paths are presented in Table 4.68 and Figure 4.9 (d). The control variables for this model were professional experience (BD2) and firm category (BD3); and were controlled in the analysis to avoid their influence on the relationship. Result shows that lean culture is positively and significantly associated with social responsibility (β = .414, C.R. = 11.929, P = ***). The effect size for this relationship is F (4, 457) = 29.545, P = .000, η^2 = .205 indicating a high effect size (**Table 4.67**). Thus, hypothesis H_7 was accepted.

H_8: The dimensions of lean culture, i.e. (a) safe working environment, (b) safety officer and supervisor, (c) reduced health and safety hazards, (d) safety training, (e) safety commitment, (f) safety incentives, (g) safety inspection and monitoring, (h) safety awareness, (i) safe activities and conditions, (j) safety concerns, (k) safety policy and (l) safety standards are positively and significantly associated with social responsibility.

H_{8a}: Safe working environment is positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe working environment (LC1) is positively and significantly associated with social responsibility (β = .150, C.R. = 3.938, P = ***). The effect size for this relationship is F (4, 457) = 18.064, P = .000, η^2 = .137 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8a} was accepted.

H_{8b}: Safety officer and supervisor are positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety officer and supervisor (LC2) is positively and significantly associated with social responsibility (β = .102, C.R. = 2.477, P = .013). The effect size for this relationship is F (4, 457) = 15.805, P = .000, η^2 = .122 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8b} was accepted.

H_{8c}: Reduced health and safety hazards are positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, reduced health and safety hazards (LC3) is negatively and significantly associated with social responsibility (β = -.093, C.R. = -2.386, P = .017). The effect size for this relationship is F (4, 457) = 8.454, P = .000, η^2 = .069 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8c} was rejected.

H_{8d}: Safety training is positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety training (LC4) is negatively and significantly associated with social responsibility (β = -.087, C.R. = -2.250, P = .024). The effect size for this relationship is F (4, 457) = 8.982, P = .000, η^2 = .073 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8d} was rejected.

H_{8e}: Safety commitment is positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety equipment (LC5) is positively and significantly associated with social responsibility (β = .230, C.R. = 5.737, P = ***). The effect size for this relationship is F (4, 457) = 12.214, P = .000, η^2 = .097 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8e} was accepted.

H_{8f}: Safety incentives are positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety incentives (LC6) is negatively and insignificantly associated with social responsibility (β = -.001, C.R. = -.035, P = .972). The effect size for this relationship is F (4, 457) = 13.204, P = .000, η^2 = .104 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8f} was rejected.

H_{8g}: Safety inspection and monitoring are positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety inspection and monitoring (LC7) is negatively and insignificantly associated with social responsibility (β = -.024, C.R. = -.549, P = .583). The effect size for this relationship is F (4, 457) = 20.636, P = .000, η^2 = .153 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8g} was rejected.

H_{8h}: Safety awareness is positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety awareness (LC8) is positively and significantly associated with social responsibility

(β = .138, C.R. = 3.320, P = ***). The effect size for this relationship is F (4, 457) = 5.388, P = .000, η^2 = .045 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8h} was accepted.

H_{8i}: Safe activities and conditions are positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe activities and conditions (LC9) is negatively and insignificantly associated with social responsibility (β = -.001, C.R. = -.030, P = .976). The effect size for this relationship is F (4, 457) = 12.123, P = .000, η^2 = .096 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8i} was rejected.

H_{8j}: Safety concerns are positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety concerns (LC10) is negatively and significantly associated with social responsibility (β = -.089, C.R. = -2.186, P = .029). The effect size for this relationship is F (4, 457) = 9.923, P = .000, η^2 = .080 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8j} was rejected.

H_{8k}: Safety policy is positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety policy (LC11) is positively and significantly associated with social responsibility (β = .125, C.R. = 2.936, P = .003). The effect size for this relationship is F (4, 457) = 17.343, P = .000, η^2 = .132 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8k} was accepted.

H_{8l}: Safety standards are positively and significantly associated with social responsibility.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety standards (LC12) is positively and significantly associated with social responsibility (β = .151, C.R. = 3.663, P = ***). The effect size for this relationship is F (4, 457) = 10.049, P = .000, η^2 = .081 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{8l} was accepted.

Thus, the hypotheses (H_7, H_{8a}, H_{8b}, H_{8e}, H_{8h}, H_{8k}, H_{8l}) were accepted, and hypotheses (H_{8c}, H_{8d}, H_{8f}, H_{8g}, H_{8i}, H_{8j}) were rejected.

H_9: Lean culture is positively and significantly associated with working environment.

Estimates of the structural paths are presented in Table 4.68 and Figure 4.9 (e). The control variables for this model were educational qualification (BD1), professional experience (BD2) and firm category (BD3); and were controlled in the analysis to avoid their influence on the relationship. Result shows that lean culture is positively and significantly associated with working environment ($\beta = .565$, C.R. = 15.160, P = ***). The effect size for this relationship is F (4, 457) = 15.253, P = .000, $\eta^2 = .118$ indicating a high effect size (**Table 4.67**). Thus, hypothesis H_9 was accepted.

H_{10}: The dimensions of lean culture, i.e. (a) safe working environment, (b) safety officer and supervisor, (c) reduced health and safety hazards, (d) safety training, (e) safety commitment, (f) safety incentives, (g) safety inspection and monitoring, (h) safety awareness, (i) safe activities and conditions, (j) safety concerns, (k) safety policy and (l) safety standards are positively and significantly associated with working environment.

H_{10a}: Safe working environment is positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe working environment (LC1) is positively and insignificantly associated with working environment ($\beta = .056$, C.R. = 1.791, P = .073). The effect size for this relationship is F (4, 457) = 10.940, P = .000, $\eta^2 = .087$ indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10a} was rejected.

H_{10b}: Safety officer and supervisor are positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety officer and supervisor (LC2) is positively and significantly associated with working environment (β= .111, C.R. = 3.276, P = .001). The effect size for this relationship is F (4, 457) = 14.524, P = .000, η^2 = .113 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10b} was accepted.

H_{10c}: Reduced health and safety hazards are positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, reduced health and safety hazards (LC3) is negatively and insignificantly associated with working environment (β = -.041, C.R. = -1.302, P = .193). The effect size for this relationship is F (4, 457) = 4.164, P = .003, η^2 = .035 indicating a medium effect size (**Table 4.67**). Hence, the hypothesis H_{10c} was rejected.

H_{10d}: Safety training is positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety training (LC4) is positively and significantly associated with working environment (β = .092, C.R. = 2.872, P = .004). The effect size for this relationship is F (4, 457) = 5.533, P = .000, η^2 = .046 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10d} was accepted.

H_{10e}: Safety commitment is positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety equipment (LC5) is positively and insignificantly associated with working environment (β = .018, C.R. = .564, P = .573). The effect size for this relationship is F (4, 457) = 8.472, P = .000, η^2 = .069 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10e} was rejected.

H_{10f}: Safety incentives are positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety incentives (LC6) is negatively and insignificantly associated with working environment (β = -.084, C.R. = -2.540, P = .011). The effect size for this relationship is F (4, 457) = 7.449, P = .000, η^2 = .061 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10f} was rejected.

H_{10g}: Safety inspection and monitoring are positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety inspection and monitoring (LC7) is positively and insignificantly associated with working environment (β = .057, C.R. = 1.622, P = .105). The effect size for this relationship is F (4, 457) = 12.328, P = .000, η^2 = .097 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10g} was rejected.

H_{10h}: Safety awareness is positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety awareness (LC8) is positively and insignificantly associated with working environment (β = .052, C.R. = 1.512, P = .130). The effect size for this relationship is F (4, 457) = 13.701, P = .000, η^2 = .107 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10h} was rejected.

H_{10i}: Safe activities and conditions are positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe activities and conditions (LC9) is positively and significantly associated with working environment (β = .114, C.R. = 3.701, P = ***). The effect size for this relationship is F (4, 457) = 10.460, P = .000, η^2 = .084 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10i} was accepted.

H_{10j}: Safety concerns are positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety concerns (LC10) is positively and insignificantly associated with working environment (β = .031, C.R. = .929, P = .353). The effect size for this relationship is F (4, 457) = 15.972, P = .000, η^2 = .123 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10j} was rejected.

H_{10k}: Safety policy is positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety policy (LC11) is positively and significantly associated with working environment (β = .123, C.R. = 3.528, P = ***). The effect size for this relationship is F (4, 457) = 18.698, P = .000, η^2 = .141 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10k} was accepted.

H_{10l}: Safety standards are positively and significantly associated with working environment.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety standards (LC12) is positively and insignificantly associated with working environment (β = .036, C.R. = 1.068, P = .285). The effect size for this relationship is F (4, 457) = 20.998, P = .000, η^2 = .155 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{10l} was rejected.

Thus, the hypotheses (H_9,H_{10b}, H_{10d}, H_{10i}, H_{10k}) were accepted, and hypotheses (H_{10a}, H_{10c}, H_{10e}, H_{10f}, H_{10g}, H_{10h}, H_{10j}, H_{10l}) were rejected.

H_{11}: Lean culture is positively and significantly associated with auditing and continuous improvement.

Estimates of the structural paths are presented in Table 4.68 and Figure 4.9 (f). The control variables for this model were educational qualification (BD1) and firm category (BD3); and were controlled in the analysis to avoid their influence on the relationship. Result shows that lean culture is positively and significantly associated with auditing and continuous improvement (β = .607, C.R. = 14.868, P = ***). The effect size for this relationship is F (4, 457) = 16.998, P = .000, η^2 = .130 indicating a high effect size (**Table 4.67**). Thus, hypothesis H_{11} was accepted.

H_{12}: The dimensions of lean culture, i.e. (a) safe working environment, (b) safety officer and supervisor, (c) reduced health and safety hazards, (d) safety training, (e) safety commitment, (f) safety incentives, (g) safety inspection and monitoring, (h) safety awareness, (i) safe activities and conditions, (j) safety concerns, (k) safety policy and (l) safety standards are positively and significantly associated with auditing and continuous improvement.

H_{12a}: Safe working environment is positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe working environment (LC1) is positively and significantly associated with auditing and continuous improvement (β = .140, C.R. = 4.684, P = ***). The effect size for this relationship is F (4, 457) = 23.696, P = .000, η^2 = .172 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12a} was accepted.

H_{12b}: Safety officer and supervisor are positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety officer and supervisor (LC2) is positively and significantly associated with auditing and continuous improvement (β = .071, C.R. = 2.195, P = .028). The effect size for this relationship is F (4, 457) = 11.981, P = .000, η^2 = .095 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12b} was accepted.

H_{12c}: Reduced health and safety hazards are positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, reduced health and safety hazards (LC3) is negatively and insignificantly associated with auditing and continuous improvement (β = -.038, C.R. = -1.272, P = .203). The effect size for this relationship is F (4, 457) = 6.979, P = .000, η^2 = .058 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12c} was rejected.

H_{12d}: Safety training is positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety training (LC4) is positively and significantly associated with auditing and continuous improvement (β = .066, C.R. = 2.214, P = .027). The effect size for this relationship is F (4, 457) = 10.975, P = .000, η^2 = .088 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12d} was accepted.

H_{12e}: Safety commitment is positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety equipment (LC5) is negatively and insignificantly associated with auditing and continuous improvement (β = -.008, C.R. = -.262, P = .793). The effect size for this relationship is F (4, 457) = 6.594, P = .000, η^2 = .055 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12e} was rejected.

H_{12f}: Safety incentives are positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety incentives (LC6) is negatively and insignificantly associated with auditing and continuous improvement (β = .000, C.R. = -.001, P = .999). The effect size for this relationship is F (4, 457) = 6.779, P = .000, η^2 = .056 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12f} was rejected.

H_{12g}: Safety inspection and monitoring are positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety inspection and monitoring (LC7) is positively and insignificantly associated with auditing and continuous improvement (β = .058, C.R. = 1.720, P = .085). The effect size for this relationship is F (4, 457) = 20.183, P = .000, η^2 = .150 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12g} was rejected.

H_{12h}: Safety awareness is positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety awareness (LC8) is positively and significantly associated with auditing and continuous improvement (v = .071, C.R. = 2.188, P = .029). The effect size for this relationship is F (4, 457) = 21.592, P = .000, η^2 = .159 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12h} was accepted.

H_{12i}: Safe activities and conditions are positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safe activities and conditions (LC9) is negatively and insignificantly associated with auditing and continuous improvement (β = -.003, C.R. = -.115, P = .908). The effect size for this relationship is F (4, 457) = 25.792, P = .000, η^2 = .184 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12i} was rejected.

H_{12j}: Safety concerns are positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety concerns (LC10) is positively and insignificantly associated with auditing and continuous improvement (β = .053, C.R. = 1.677, P = .093). The p-values for all these variables were less than 1.96. All these values of estimates, CR and significance (p-value) values indicated that AC was positively and significantly associated with LC1, LC2, LC4, LC8, LC11 and LC12. To be concluded, LL was positively and significantly associated with 5 dimensions out of 12. The effect size for this relationship is F (4, 457) = 14.536, P = .000, η^2 = .113 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12j} was rejected.

H_{12k}: Safety policy is positively and significantly associated with auditing and continuous improvement.

Table 4.69 and Figure 4.10 present that the dimension of lean culture, safety policy (LC11) is positively and significantly associated with auditing and continuous improvement (β = .080, C.R. = 2.414, P = .016). The effect size for this relationship is F (4, 457) = 15.244, P = .000, η^2 = .118 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12k} was accepted.

H_{12l}: Safety standards are positively and significantly associated with auditing and continuous improvement.

Table 4.69 and **Figure 4.10** present that the dimension of lean culture, safety standards (LC12) is positively and significantly associated with auditing and continuous improvement (β = .066, C.R. = 2.040, P = .041). The effect size for this relationship is F (4, 457) = 12.305, P = .000, η^2 = .097 indicating a high effect size (**Table 4.67**). Hence, the hypothesis H_{12l} was accepted.

Thus, the hypotheses (H_{11}, H_{12a}, H_{12b}, H_{12d}, H_{12h}, H_{12k}, H_{12l}) were accepted, and hypotheses (H_{12c}, H_{12e}, H_{12f}, H_{12g}, H_{12i}, H_{12j}.) were rejected.

4.3.1 Overview of Hypotheses

The following segment of this chapter shows the overview of the hypotheses tested and the emerging outcomes including the accepted or rejected status of each hypothesis. Table 4.70 presents a detailed outline of the relationships analysed in this research study including an examination of lean culture (composite and multidimensional style) with outcome variables (i.e., lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement).

TABLE 4.70: Summary of Hypotheses

Hypothesis	Statements	Results
$\mathbf{H}_1$	Lean culture is positively and significantly associated with lean leadership.	Accepted
$\mathbf{H}_{2a}$	Safe working environment is positively and insignificantly associated with lean leadership.	Rejected
$\mathbf{H}_{2b}$	Safety officer and supervisor are positively and significantly associated with lean leadership.	Accepted
$\mathbf{H}_{2c}$	Reduced health and safety hazards are positively and insignificantly associated with lean leadership.	Rejected
$\mathbf{H}_{2d}$	Safety training is positively and insignificantly associated with lean leadership.	Rejected
$\mathbf{H}_{2e}$	Safety commitment is positively and insignificantly associated with lean leadership.	Rejected
$\mathbf{H}_{2f}$	Safety incentives are positively and significantly associated with lean leadership.	Accepted
$\mathbf{H}_{2g}$	Safety inspection and monitoring are positively and insignificantly associated with lean leadership.	Rejected
$\mathbf{H}_{2h}$	Safety awareness is positively and significantly associated with lean leadership.	Accepted

$\mathbf{H}_{2i}$	Safe activities and conditions are positively and insignificantly associated with lean leadership.	Rejected
$\mathbf{H}_{2j}$	Safety concerns are positively and insignificantly associated with lean leadership.	Rejected
$\mathbf{H}_{2k}$	Safety policy is positively and significantly associated with lean leadership.	Accepted
$\mathbf{H}_{2l}$	Safety standards are positively and significantly associated with lean leadership.	Accepted
$\mathbf{H}_{3}$	Lean culture is positively and significantly associated with teamwork.	Accepted
$\mathbf{H}_{4a}$	Safe working environment is positively and insignificantly associated with teamwork.	Rejected
$\mathbf{H}_{4b}$	Safety officer and supervisor are positively and significantly associated with teamwork.	Accepted
$\mathbf{H}_{4c}$	Reduced health and safety hazards are positively and insignificantly associated with teamwork.	Rejected
$\mathbf{H}_{4d}$	Safety training is positively and insignificantly associated with teamwork.	Rejected
$\mathbf{H}_{4e}$	Safety commitment is positively and insignificantly associated with teamwork.	Rejected
$\mathbf{H}_{4f}$	Safety incentives are negatively and significantly associated with teamwork.	Rejected
$\mathbf{H}_{4g}$	Safety inspection and monitoring are positively and significantly associated with teamwork.	Accepted
$\mathbf{H}_{4h}$	Safety awareness is positively and insignificantly associated with teamwork.	Rejected
$\mathbf{H}_{4i}$	Safe activities and conditions are positively and insignificantly associated with teamwork.	Rejected
$\mathbf{H}_{4j}$	Safety concerns are negatively and insignificantly associated with teamwork.	Rejected
$\mathbf{H}_{4k}$	Safety policy is positively and significantly associated with teamwork.	Accepted

$\mathbf{H}_{4l}$	Safety standards are positively and significantly associated with teamwork.	Accepted
$\mathbf{H}_{5}$	Lean culture is positively and significantly associated with management role.	Accepted
$\mathbf{H}_{6a}$	Safe working environment is positively and significantly associated with management role.	Accepted
$\mathbf{H}_{6b}$	Safety officer and supervisor are positively and significantly associated with management role.	Accepted
$\mathbf{H}_{6c}$	Reduced health and safety hazards are positively and insignificantly associated with management role.	Rejected
$\mathbf{H}_{6d}$	Safety training is negatively and insignificantly associated with management role.	Rejected
$\mathbf{H}_{6e}$	Safety commitment is positively and significantly associated with management role.	Accepted
$\mathbf{H}_{6f}$	Safety incentives are positively and insignificantly associated with management role.	Rejected
$\mathbf{H}_{6g}$	Safety inspection and monitoring are positively and significantly associated with management role.	Accepted
$\mathbf{H}_{6h}$	Safety awareness is positively and insignificantly associated with management role.	Rejected
$\mathbf{H}_{6i}$	Safe activities and conditions are negatively and significantly associated with management role.	Rejected
$\mathbf{H}_{6j}$	Safety concerns are negatively and significantly associated with management role.	Rejected
$\mathbf{H}_{6k}$	Safety policy is positively and significantly associated with management role.	Accepted
$\mathbf{H}_{6l}$	Safety standards are positively and insignificantly associated with management role.	Rejected
$\mathbf{H}_{7}$	Lean culture is positively and significantly associated with social responsibility.	Accepted

$\mathbf{H}_{8a}$	Safe working environment is positively and significantly associated with social responsibility.	Accepted
$\mathbf{H}_{8b}$	Safety officer and supervisor are positively and significantly associated with social responsibility.	Accepted
$\mathbf{H}_{8c}$	Reduced health and safety hazards are negatively and significantly associated with social responsibility.	Rejected
$\mathbf{H}_{8d}$	Safety training is negatively and significantly associated with social responsibility.	Rejected
$\mathbf{H}_{8e}$	Safety commitment is positively and significantly associated with social responsibility.	Accepted
$\mathbf{H}_{8f}$	Safety incentives are negatively and insignificantly associated with social responsibility.	Rejected
$\mathbf{H}_{8g}$	Safety inspection and monitoring are negatively and insignificantly associated with social responsibility.	Rejected
$\mathbf{H}_{8h}$	Safety awareness is positively and significantly associated with social responsibility.	Accepted
$\mathbf{H}_{8i}$	Safe activities and conditions are negatively and insignificantly associated with social responsibility.	Rejected
$\mathbf{H}_{8j}$	Safety concerns are positively and negatively associated with social responsibility.	Rejected
$\mathbf{H}_{8k}$	Safety policy is positively and significantly associated with social responsibility.	Accepted
$\mathbf{H}_{8l}$	Safety standards are positively and significantly associated with social responsibility.	Accepted
$\mathbf{H}_{9}$	Lean culture is positively and significantly associated with working environment.	Accepted
$\mathbf{H}_{10a}$	Safe working environment is positively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{10b}$	Safety officer and supervisor are positively and significantly associated with working environment.	Accepted

$\mathbf{H}_{10c}$	Reduced health and safety hazards are negatively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{10d}$	Safety training is positively and significantly associated with working environment.	Accepted
$\mathbf{H}_{10e}$	Safety commitment is positively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{10f}$	Safety incentives are negatively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{10g}$	Safety inspection and monitoring are positively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{10h}$	Safety awareness is positively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{10i}$	Safe activities and conditions are positively and significantly associated with working environment.	Accepted
$\mathbf{H}_{10j}$	Safety concerns are positively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{10k}$	Safety policy is positively and significantly associated with working environment.	Accepted
$\mathbf{H}_{10l}$	Safety standards are positively and insignificantly associated with working environment.	Rejected
$\mathbf{H}_{11}$	Lean culture is positively and significantly associated with auditing and continuous improvement.	Accepted
$\mathbf{H}_{12a}$	Safe working environment is positively and significantly associated with auditing and continuous improvement.	Accepted
$\mathbf{H}_{12b}$	Safety officer and supervisor are positively and significantly associated with auditing and continuous improvement.	Accepted
$\mathbf{H}_{12c}$	Reduced health and safety hazards are negatively and insignificantly associated with auditing and continuous improvement.	Rejected

$\mathbf{H}_{12d}$	Safety training is positively and significantly associated with auditing and continuous improvement.	Accepted
$\mathbf{H}_{12e}$	Safety commitment is negatively and insignificantly associated with auditing and continuous improvement.	Rejected
$\mathbf{H}_{12f}$	Safety incentives are negatively and insignificantly associated with auditing and continuous improvement.	Rejected
$\mathbf{H}_{12g}$	Safety inspection and monitoring are positively and insignificantly associated with auditing and continuous improvement.	Rejected
$\mathbf{H}_{12h}$	Safety awareness is positively and significantly associated with auditing and continuous improvement.	Accepted
$\mathbf{H}_{12i}$	Safe activities and conditions are negatively and insignificantly associated with auditing and continuous improvement.	Rejected
$\mathbf{H}_{12j}$	Safety concerns are positively and insignificantly associated with auditing and continuous improvement.	Rejected
$\mathbf{H}_{12k}$	Safety policy is positively and significantly associated with auditing and continuous improvement.	Accepted
$\mathbf{H}_{12l}$	Safety standards are positively and significantly associated with auditing and continuous improvement.	Accepted

Total number of hypotheses: 78

Accepted: 36

Rejected: 42

4.4 Discussion

This study examined the concept of lean culture, which was developed and established in the Toyota company with limited insights into the South Asian culture

[233]. This study filled this gap by investigating the influence of dimensions of lean culture style on safety outcomes. This study aimed to examine the association between the twelve-dimensional model of lean culture and outcomes, i.e., lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement. Literature suggested that lean culture is associated positively with positive outcomes and negatively associated with dysfunctional outcomes [234]. Furthermore, this study meaningfully extended the previous findings and confirmed the multi-dimensions of lean culture, which contributes differently toward outcomes.

Hypotheses were formulated in six major groups which were related to the twelve dimensions of lean culture and the six outcomes (lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement). Thus, a total of seventy-two (72) hypotheses related to the impact of dimensions of lean culture on outcomes were developed. The relationship between twelve dimensions of lean culture and lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement were expanded through H_{2a} to H_{2l}, H_{4a} to H_{4l}, H_{6a} to H_{6l}, H_{8a} to H_{8l}, H_{10a} to H_{10l} and H_{12a} to H_{12l}, respectively. Thirty hypotheses were accepted, while the following forty-two hypotheses were rejected:

H_{2a}, H_{2c}, H_{2d}, H_{2e}, H_{2g}, H_{2i}, H_{2j}, H_{4a}, H_{4c}, H_{4d}, H_{4e}, H_{4f}, H_{4h}, H_{4i}, H_{4j}, H_{6c}, H_{6d}, H_{6f}, H_{6h}, H_{6i}, H_{6j}, H_{6l}, H_{8c}, H_{8d}, H_{8f}, H_{8g}, H_{8i}, H_{8j}, H_{10a}, H_{10}c, H_{10e}, H_{10f}, H_{10g}, H_{10h}, H_{10j}, H_{10l}, H_{12c}, H_{12e}, H_{12f}, H_{12g}, H_{12i} and H_{12j}.

Results of this study confirmed that lean culture was a multidimensional construct across the cultural setting, thus finding support for the results. In addition, out of twelve dimensions, the results indicated that in the South Asian setting, safety officer and supervisor, and safety policy significantly influenced the safety outcomes. Whereas, safe working environment, safety awareness and safety standards considerably influenced safety outcomes. Lastly, safety incentives, and safe activities and conditions had limited influence on the outcome variables. One of the possible reasons is that safety incentives, and safe activities and conditions are such traits which are perceived differently in South Asia and may manifest themselves in other behaviours, such as safe working environment, safety awareness and safety standards. Therefore, respondents observed safety incentives, and safe activities and conditions as a part of other traits. In addition, inconsistency in leadership behaviour and trust also contributes to producing limited association of safety incentives, and safe activities and conditions. This finding is imperative as this was not possible using a unidimensional scale of lean culture. Thus, this study provided deep insights into the concepts of lean culture.

The results of this study suggested that every dimension of lean culture was related to outcome variables in a unique way. Thus, each dimension of lean culture, with the support of other dimensions, either enhanced or decreased the impact on outcomes. Therefore, it was significant to establish a blend of dimensions that helped to attain desired outcomes. Hence, it was critical maintaining a sensible combination of all the twelve dimensions of lean culture.

This empirical study contributed to the body of knowledge by examining the relationship between lean culture and its influence on significant outcomes. To find out the relationship, six hypotheses were formulated which examined the relationship of the composite form of lean culture with six outcomes (lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement) through H_1, H_3, H_5, H_7, H_9 and H_{11}. The statistical analyses of this study revealed that lean culture was positively associated with lean leadership (H_1), teamwork (H_3), management role (H_5), social responsibility (H_7), working environment (H_9) and auditing and continuous improvement (H_{11}).

4.5 Summary

In this chapter, a detailed discussion of the analytical approaches used to examine the proposed relationships between the data collected through SPSS and AMOS has been presented. Before proceeding to hypothesis testing, this chapter outlines the details of the analysis conducted to establish the statistical significance of the data collected through EFA, and CFA to authenticate the structure of the collected data. Further, collected data were examined for normal distribution, skewness and kurtosis analysis and multicollinearity using the test of tolerance and VIF. Upon successful outcomes of the aforementioned tests, this research study conducted a correlation coefficient analysis for the proposed model. In addition, this chapter also examined the analysis of control variables and their association with outcome variables, i.e., lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement. Followed by the aforementioned statistical analysis, this study proceeded with the evaluation of the proposed relationships by testing the direct relationship of predictor criterion, i.e., the direct relationship between the composite and multidimensional forms of lean culture with outcome variables (lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement). The results of the direct relationships between the composite form of lean culture and outcome variables were significantly correlated. All these relationships were tested using SPSS and AMOS and represent the emerging results in the form of tables and figures. This chapter also presented a summary of all the hypotheses tested and their subsequent results. Overall, the results supported approximately half the proposed hypotheses.

Chapter 5

Conclusion and Recommendations

This chapter deals with the conclusions and recommendations based on the data analysis as well as suggests the directions for future research.

5.1 Conclusion

The purpose of this study was to explore the concept of lean culture and its role in safety management on construction sites in Pakistan. The Delphi technique was applied to shortlist the identified factors. Variables were categorized into six dependent variables; lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement, and various independent variables to present a multi-dimensional form of lean culture. 550 questionnaires were distributed and 462 filled questionnaires were received back with a response rate of 84%.

Some statistical analyses were performed based on which it was concluded that lean culture ensured health and safety management through lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement. Lean leadership had a significant role in safety officer and supervisor, safety incentives, safety awareness, safety policy and safety standards. Teamwork had a significant role in safety officer and supervisor, safety inspection and monitoring, safety policy and safety standards. Management role had a significant impact on safe working environment, safety officer and supervisor, safety commitment, safety inspection and monitoring, and safety policy. Social responsibility had a significant role in safe working environment, safety officer and supervisor, safety commitment, safety awareness, safety policy and safety standards. Working environment had a significant impact on safety officer and supervisor, safety training, safe activities and conditions, and safety policy. Auditing and continuous improvement had a significant role in safe working environment, safety officer and supervisor, safety training, safety awareness, safety policy and safety standards. The statistical conclusions drawn from conducted analyses are as follows:

- Reliability statistics (Cronbach's Alpha) for variables of lean culture, lean leadership, teamwork, management role, social responsibility, working environment and auditing and continuous improvement were 0.928, 0.958, 0.906, 0.940, 0.890, 0.942 and 0.924 respectively. All values are greater than the threshold value, 0.7, so all dependent variables have excellent reliability except social responsibility which has good reliability.

- Skewness values for all main variables ranged between -0.911 to +0.055, which are less than 2, and the Kurtosis values were less than 7 so the sample data was normally distributed.

- In one-way ANOVA test, qualification was found significant with LL, WE and AC. Experience was significant with TW, SR and WE. Firm category and gender were found significant with LL, TW, MR, SR, WE and AC.

- KMO value obtained, 0.853, indicated that sampling data was meritorious. Bartlett's estimated a value of 0.000 which means all variables are correlated with each other.

- In EFA, factor loadings for all variables were greater than 0.3 so all variables were included for further analysis.

SEM was used for simultaneous assessment of several variables and their interrelationships. More than one CFA analysis were conducted for the model to validate the factor analysis and its outcomes.

- Results of first-order CFA converged into a good model-fit (χ^2/df = 1.387, GFI = .913, AGFI = .930, NFI = .913, TLI = .912, CFI = .909 and RMSEA = .076) and validated the construct validity through meeting the threshold values of all model-fit indices.

- Results of second-order CFA converged into a significant model-fit (χ^2/df = 1.880, GFI = .939, AGFI = .906, NFI = .954, TLI = .917, CFI = .928 and RMSEA = .073).

- Results of the consolidated CFA indicated almost acceptable model-fit values (χ^2/df = 2.03, GFI = .895, AGFI = .876, NFI = .902, TLI = .881, CFI = .889 and RMSEA = .081).

- To achieve a superior fitting model, post hoc adjustments were made to the consolidated model, by correlating the error variables of the dependent variables, resulting in a good-fit model (χ^2/df = 1.903, GFI = .916, AGFI = .905, NFI = .925, TLI = .902, CFI = .901 and RMSEA = .077).

To assess the normality of the model, univariate and multivariate normality were calculated in Amos using Skewness and Kurtosis test.

- All the variables showed univariate normality as Skewness and Kurtosis values for each variable were less than 3 and 7 respectively.

- The variables in the analysis reflected multivariate normality as multivariate kurtosis and multivariate c.r. values were much higher.

- By calculating squared Mahalanobis distance value for each case, the case number 313 was found as an outlier which was causing multivariate normality.

- Adopting bootstrapping procedure, the case number 313 was removed to achieve the multivariate normality.

- In multi-collinearity test, no collinearity was found among any variable as Tolerance values were much larger than 0.2, VIF and condition index values were less than 5 and 15 respectively, and none of the Eigen values among the variables was close to zero.
- In correlation analysis, all correlations were found positive and significant except some demographic variables.
- In effect size analysis, almost all variables had strong or intermediate relation with each other except some few which had weak relationship.

Therefore, based on conducted study, the following practical guidance for the construction industry is offered.

- Launch safety incentive programs to reduce injuries and accidents in the workplace. Further, they help in reducing the company's care costs and the time loss that comes with injury and disability.
- Development of workplace safety policies to identify hazards to protect the employees.
- Adoption of safety standards to eliminate risks which cause worker injuries, illness and fatalities, and reduce the claims costs and reputation damage spurred by workplace incidents.
- Conduction of training programs to spread safety awareness to all employees and ensuring a safe working environment and limit the activities vulnerable to safety.

Government support such as introducing incentive programs and launching regulations enabling lean practices is essential for the success of lean implementation and construction safety. Along with these steps, construction industry should also implement six factors of lean culture i.e. lean leadership, teamwork, management role, social responsibility, working environment and continuous improvement to ensure health and safety management.

5.2 Future Recommendations

This study offers the following practical guidance for the construction industry.

- Development of workplace safety policies to identify hazards to protect the employees.
- Adoption of safety standards to eliminate risks which cause worker injuries, illness and fatalities, and reduce the claims costs and reputation damage spurred by workplace incidents.
- Ensuring a safe working environment and limit the activities vulnerable to safety.
- Guide for training programs to spread safety awareness to all employees.
- Launch safety incentive programs to reduce injuries and accidents in the workplace. Further, they help in reducing the company's care costs and the time loss that comes with injury and disability.

Government support such as introducing incentive programs and launching regulations enabling lean practices is essential for the success of lean implementation and construction safety.

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Appendix

Questionnaire

Dear Respondent

I am a master candidate at the Capital University of Science & Technology, Islamabad. I am collecting data for my MS dissertation. Please fill in the following questionnaire which is about lean culture and its effects on safety and health in the construction industry of Pakistan. Your response will be of great value for the completion of this research study.

The questionnaire attached is part of research work for my Master of civil engineering, entitled "Innovating Role of Lean Culture in Health and Safety Management at Construction Sites of Pakistan". In many countries in the world, the construction industry plays a big role in the development process which contributes to the economic growth that generates additional demands for construction activities. The construction industry is one of the main economic pillars of our industry. However, the record of Health and Safety issues in compliance with OSHA Standards is not encouraging. So many projects suffer due to the issue of non-compliance with health and safety requirements. Ultimately, the projects are not only becoming uneconomical but also promoting the 3D Image (Dirty, Difficult and Dangerous) of this sector. Besides many other factors, the lean culture for OSHA implementations remains one of the major barriers. So, it is very important to investigate the role of lean culture in promoting and enhancing our safety standards. This would not only address the safety concerns but also give a handsome economic burden as a result of safety issues.

The feedback from the industry professionals remains the key to a successful investigation of a known issue. Please answer the questions for the identified concerns up to the best of your professional expertise to investigate the role of lean culture in health and safety management at construction projects. This would enable us to achieve vital feedback to develop a framework for the prioritized variables. Your kind cooperation is highly requested.

Sincerely,

Aown Muhammad,

Email: makhdoomaown@gmail.com

MS Research Scholar,

Department of Civil Engineering,

Capital University Science and Technology, Islamabad.

Section 1: Demographic Data

Qualification	1 (Bachelor) 2 (MS), 3 (PhD), 4 (Other)
Professional Experience	1 (Less than 5), 2 (5–10), 3 (11-15), 4 (16-20), 5 (20-above)
Firm Category (as per PEC rules)	1 (C6), 2 (C5), 3 (C4), 4 (C3), 5 (C2), 6 (C1), 7 (C-B), 8 (C-A), 9 (Others)
Gender	1- Male 2- Female

Section 2: Lean Culture in Health and Safety Management

Lean culture helps people understand the critical functions of Lean practices and facilitates the lean implementation process ensuring health and safety on the project site. The impact is the measure of the extremity of such factors on the project objective (Health and Safety) with the Likert Scale i.e., Very Low = 1, Low = 2, Moderate = 3, High = 4, and Very High = 5. Keeping in view the above criteria, what will be the impact of identified factors in your perspective? Please mark one box for impact level.

1. Lean Culture

Sr.No	**Variables**	**Impact**				
		Very Low	Low	Moderate	High	Very High
1	Safe Working Environment	1	2	3	4	5
2	Safety Officer and Supervisor	1	2	3	4	5
3	Reduced Health and Safety Hazards	1	2	3	4	5
4	Safety Training	1	2	3	4	5
5	Safety Commitment	1	2	3	4	5
6	Safety Incentives	1	2	3	4	5
7	Safety Inspection and Monitoring	1	2	3	4	5
8	Safety Awareness	1	2	3	4	5
9	Safe activities and Conditions	1	2	3	4	5
10	Safety Concerns	1	2	3	4	5
11	Safety Policy	1	2	3	4	5
12	Safety Standards	1	2	3	4	5

2. Lean Leadership

Lean leadership carefully addresses the philosophy, process, people and partners, and problem-solving, which is a key component of sustainable lean implementation.

Sr.No	**Variables**	**Impact**				
		Very Low	Low	Moderate	High	Very High
1	Shareholders Commitment to Lean Construction Principles	1	2	3	4	5
2	Rules and Regulations	1	2	3	4	5
3	People Development based on Lean Thinking	1	2	3	4	5
4	Decisions based on Data and Facts	1	2	3	4	5
5	Leading with Humility	1	2	3	4	5
6	Constancy of Purpose	1	2	3	4	5
7	Motivation	1	2	3	4	5
8	Promotions	1	2	3	4	5
9	Reward Systems	1	2	3	4	5
10	Guiding Principles	1	2	3	4	5
11	Encouraging Employees to Try New Ideas	1	2	3	4	5
12	Willingness to invest in Lean Practices	1	2	3	4	5
13	Strategic Actions	1	2	3	4	5
14	Treating controlled failures as learning labs	1	2	3	4	5

3. Team Work

More people have to collaborate with others in their work for the speed of change, fast schedules, and variety of expertise required for most tasks.

Sr.No	Variables	Impact				
		Very Low	Low	Moderate	High	Very High
1	Team Support	1	2	3	4	5
2	Commitment	1	2	3	4	5
3	Engagement	1	2	3	4	5
4	Shared Meaningful Goal	1	2	3	4	5
5	Employee Morale	1	2	3	4	5

4. Management Role

The role of the Lean Project Manager, at a strategic level and across all projects, is to educate all parties involved in construction on lean thinking, principles and techniques and to provide advice and guidance as to how to optimize the processes associated with lean.

Sr.No	Variables	Impact				
		Very Low	Low	Moderate	High	Very High
1	Encourage Decisions	1	2	3	4	5
2	Concern and Respect for Employees	1	2	3	4	5
3	Safety and Health Pre-occupation for work-force and labors	1	2	3	4	5
4	Recognition and Celebration of Small and Big Victories	1	2	3	4	5

5	Allowing People to Make Mistakes and Learn from them (Learning and Experimenting within the Company)	1	2	3	4	5
6	Treating all people with dignity	1	2	3	4	5
7	Opportunities to Employees to Flourish	1	2	3	4	5
8	Management Commitment	1	2	3	4	5
9	Performance Evaluations	1	2	3	4	5
10	Planning and Staffing for Safety	1	2	3	4	5

5. Social Responsibility

Government support such as launching regulations enabling lean practices is essential for the success of lean practices and lean implementation.

Sr.No	**Variables**	**Impact**				
		Very Low	Low	Moderate	High	Very High
1	Healthy Habits	1	2	3	4	5
2	Supportive Nature of Governmental Regulations in Lean	1	2	3	4	5
3	Government Incentives	1	2	3	4	5

4	Availability of Resources for Lean	1	2	3	4	5

6. Working Environment

The availability of lean tools, techniques, and software systems is essential to establishing a lean-friendly environment in construction projects.

Sr.No	**Variables**	**Impact**				
		Very Low	Low	Moderate	High	Very High
1	Trust	1	2	3	4	5
2	Communication Processes	1	2	3	4	5
3	Team Spirit	1	2	3	4	5
4	Elimination of Fear	1	2	3	4	5
5	Respect for People	1	2	3	4	5
6	Worker Behaviour	1	2	3	4	5
7	Innovations in Processes	1	2	3	4	5
8	A Clear Understanding of Technical Requirements in Lean Practices	1	2	3	4	5
9	The Existence of Clear Roles in Lean	1	2	3	4	5
10	The Existence of Lean Research Groups and Initiatives	1	2	3	4	5
11	Target Value Delivery	1	2	3	4	5

7. Auditing and Continuous Improvement

Continuous improvement is done by embracing new challenges and expanding its horizons towards sustainability, digitalisation and social responsibility.

Sr.No	**Variables**	**Impact**				
		Very Low	Low	Moderate	High	Very High
1	Continuous Education	1	2	3	4	5
2	Encouraging and Helping Employees	1	2	3	4	5
3	Standardised Task and Processes	1	2	3	4	5
4	Top-down Management	1	2	3	4	5
5	Go and See	1	2	3	4	5
6	Creative Thinking	1	2	3	4	5
7	Problem Solving	1	2	3	4	5
8	Collaborative Practices	1	2	3	4	5
9	Customer Satisfaction	1	2	3	4	5

We are thankful to you for your effort and support in responding to this survey. Collecting this type of information enables us to understand and develop better safety and health management in the workplace that will have a positive impact on the lives of many workers. Upon the completion of this research investigation, we would like to share the summary of the results with you.

Your name: –

Your organization name: –

Please provide your email ID: –

My email is: makhdoomaown@gmail.com