STUDY OF THE WORKPLACE ACCIDENTS CAUSED BY HUMAN ERROR IN THE MANUFACTURING INDUSTRY USING STRUCTURAL EQUATION MODELLING (SEM)

NATALEE CORBETT

UNIVERSITI TUNKU ABDUL RAHMAN

STUDY OF THE WORKPLACE ACCIDENTS CAUSED BY HUMAN ERROR IN THE MANUFACTURING INDUSTRY USING STRUCTURAL EQUATION MODELLING (SEM)

NATALEE CORBETT

A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering (Honours) Mechanical Engineering

Lee Kong Chian Faculty of Engineering and Science
Universiti Tunku Abdul Rahman

April 2022

COMMENTS ON FYP REPORT

Name: Natalee Corbett Student ID: 18UEB04789

Supervisor: Mr. Cheong Wen Chiet

Moderator: Dr. Liang Meng Suan

Comments by: **Supervisor/Moderator** (delete where not applicable)

Option 1

☐ Marking and give comments on the pdf/word FYP report

Option 2

☐ Marking and give comments on below

Comments on FYP Report

No.	Criteria	Comments
1	Abstract	
2	Introduction	
3	Literature Review	
4	Methodology	
5	Results & Discussion	
6	Conclusion and Recommendation	
7	References	
8	Any other comments	

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

Signature :

Name : Natalee Corbett

ID No. : 18UEB04789

Date : 24th April 2022

APPROVAL FOR SUBMISSION

I certify that this project report entitled **"STUDY OF THE WORKPLACE ACCIDENTS CAUSED BY HUMAN ERROR IN THE MANUFACTURING INDUSTRY USING STRUCTURAL EQUATION MODELLING (SEM)"** was prepared by **NATALEE CORBETT** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Engineering (Honours) Mechanical at Universiti Tunku Abdul Rahman.

Approved by,

Signature : CWC

Supervisor : Cheong Wen Chiet

Date : 24/04/2022

ACKNOWLEDGEMENTS

I would like to express my enormous appreciation to everyone who has helped me in their contribution towards completing this final year project report where it would have been impossible for me to complete this report without their guidance and support.

I would also like to express my sincere gratitude to my research supervisor, Mr. Cheong Wen Chiet for his enormous patience, dedication and guidance throughout this research. He has been an invaluable support while facing the challenges and problems encountered while completing this report.

In addition, I would also like to express my appreciation to my family who have been understanding and emotionally supportive throughout this journey and have encouraged me in completing this report. Lastly, I would like to thank my friends and course mates who have helped me and lent a helping hand in finishing this report while conducting this study.

ABSTRACT

In the manufacturing industry, human error is an aspect that is a common occurrence. This can happen whether intentional or unintentional and may affect the flow of work in the plant depending on the severity of the error. The purpose of this study is to examine the relationship between safety knowledge, unsafe behaviour and workplace accidents to human error. The focus of this study is on the manufacturing industry in Malaysia. The total number of respondents that were sampled in this study was 117 respondents who were recruited by sending out Google Form surveys from various parts of the country. Based on the demographic profile of the respondents, most of the respondents are located in Penang and are working in large sized companies with the number of full-time employees being more than 200 in the electrical and electronics industry as Engineers. The survey results were then studied using SmartPLS in order to find out the correlation between safety knowledge, unsafe behaviour and workplace accidents to human error. Since the values of the loadings for each of the items are more than 0.5, with a range of 0.778 to 0.929, they are considered to be reliable. Other than that, the results show that there is a significant positive impact of unsafe behaviour to human error with the largest factor loading of 0.437. Besides that, since there are positive values for the values of the loadings between the independent and the dependent variables, that is more than 0, it can be concluded that there is a positive relationship between the Safety Knowledge, Unsafe Behaviour and Workplace Environment to Human Error. In conclusion, the factor loading of workplace environment to human error is 0.252 which also shows that there is a significant positive impact of workplace environment to human error. Lastly, safety knowledge also is found to have a significant positive impact on human error with a factor loading of 0.152. The results obtained from this study can be used in order to take into account and further explore the relevance of the relationship between these variables.

TABLE OF CONTENTS

CHAPTER

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS / ABBREVIATIONS

HE	Human Error
HE1	Human Error Question 1
HE2	Human Error Question 2
HE3	Human Error Question 3
HE4	Human Error Question 4
HE5	Human Error Question 5
SK	Safety Knowledge
SK4	Safety Knowledge Question 4
SK5	Safety Knowledge Question 5
UB	Unsafe Behaviour
UB1	Unsafe Behaviour Question 1
UB2	Unsafe Behaviour Question 2
UB3	Unsafe Behaviour Question 3
UB4	Unsafe Behaviour Question 4
UB5	Unsafe Behaviour Question 5
WE	Workplace Environment
WE1	Workplace Environment Question 1
WE2	Workplace Environment Question 2
WE3	Workplace Environment Question 3
WE4	Workplace Environment Question 4
WE5	Workplace Environment Question 5

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Human errors are due to human factors which can be explained as the way of understanding the interaction of different people, their weaknesses and strengths and the pursuit of a person in order to find out ways of improving the carrying out of tasks. In this way, the managers and manufacturing safety professionals can have a greater way of understanding how the manufacturing industry works and the organisational hierarchy (Mohammadfam et al. 2021).

There are many ways to classify human error according to classifications such as by psychological, unsafe practices, behavioural or others in the manufacturing industry. In order to elaborate, in the psychological context, human error may happen in the process of carrying out their specified responses to a particular situation which may also be divided into different groupings such as skill-based which comprises of slips and lapses in judgement, mistakes which comprises of either rule or knowledge-based mistakes and also violations of standard operating procedures (SOP). Unsafe behaviour may be contributed by the inadequacy of training by the supervisors or management or fatigue which may cause the workers to want to be able to finish their work in a quick fashion without regard to their own safety or others. Some of the behavioural causes of human error may be due to problems in the organisational aspect for example, lack of communication between the management and employee, competition with other contractors, cost issues, insufficient pre-planning of the project or also lack of consistent maintenance of the tools and machines (Mohammadfam et al., 2021).

According to the Department of Statistics Malaysia, 2021, based on the occupational accident data provided by the Department of Occupational Safety and Health (DOSH) and Social Security Organisation (SOCSO), Ministry of Human Resources, in 2020, there was an accident rate of 2.18 per 1000 workers with as many as 32,674 occupational accidents where there was an occupational fatality rate of 2.09 per 100,000 workers. Of these occupational accidents, the highest number of accidents recorded was 10,303 accidents which occurred in the manufacturing industry with 83 fatalities. The breakdowns of the occupational accidents were caused by 3 types of accidents namely, fall of persons with 7885 accidents and 88 deaths which were caused by stepping against or being struck by objects, including falling objects with 7285 accidents and 84 deaths and lastly, unclassified accidents with 5351 accidents and 21 deaths. This shows that the manufacturing industry is one of the most dangerous among all other industries due to there being such a high number of accidents and deaths in comparison.

This study is performed in order to assess the causes of workplace accidents due to human errors in the manufacturing industry. Some of the variables affecting human error that can be studied that affect the occurrences of workplace accidents are such as safety knowledge, workplace environment and safety behaviour which will be studied in the upcoming Chapter 2.

Structural equation modelling (SEM) will be used in the analysis of this study which is frequently used for accident or incident analysis, safety management and in many other fields.

1.2 Importance of the Study

Workplace accidents are very common not only in the manufacturing industry but also in all types of plants and factories all around the world. There are various levels of severity of workplace accidents where the most severe is the loss of a life.

The importance of this study is to analyse the causes of human error to help in reducing the occurrences of workplace accidents using Structural Equation Modelling. It is impossible to create or design a plant that has totally no human error due to the fact that it is an inherent behaviour of any technological system. Hence, the level of safety in a plant can be improved by executing the necessary steps and measures in order to develop human skills and the potential of the automated systems in order to minimise the occurrences of errors in a system. This can reduce the likelihood of having to alleviate the consequences of errors that still occur and can be recovered that may cause damage to the plant and cause irreparable or costly damage (Mohammadfam et al, 2021).

In conclusion, this study will be able to help make a contribution towards other research of the causes of workplace accidents caused by human error in the manufacturing industry where the factors investigated are safety knowledge, workplace environment and unsafe behaviour. The improvement of the safety of any system can only be made when there are appropriate measures developed in order to promote awareness, cautiousness, safety, recovery, isolation and escape from hazards and accidents (Mohammadfam et al., 2021). Hence, there will be more awareness towards the severity human error in workplace accidents which will help to make advancement towards further research to ensure the safety of the workforce.

1.3 Problem Statement

Human error is one of the main causes of workplace accidents that are related to factors such as safety knowledge, workplace environment and unsafe behaviour. Although the manufacturing industry is widely incorporated with modern technology in the design of the process and during the instalment process, there is still a need for human intervention due to the unstable characteristics of hardware that can cause problems in the manufacturing cycle where unplanned and unexpected occurrences of human error and failure in hardware mechanisms causes interruptions to the manufacturing process and causes industrial accidents to happen (Reyes, 2015). Through various studies it has been proven that human error is the major cause of industrial accidents (Hale, 1987; Runciman, 1990; Reason, 1990; Salminen, 1996; Feyer, 1997; Reyes, 2012).

The identification of the significance of human error in the occurrence of workplace incidents is further complicated by the entanglement of the relationship between the technological systems and organisations and human interface where the probability of accidents occurring is high. According to Zakaria, et al., 2012, the occurrence of accidents may pose a large risk to safety especially when it involves the handling of large and complex machinery where there are many ways besides human error that may cause the occurrence of workplace accidents. Thus, it is important to understand the reasons why accidents happen in order to prevention as well as to find a solution in order to reduce to possibility of the occurrence of workplace accidents.

1.4 Aim and Objectives

The aim of this study is to analyse elements that contribute to workplace accidents caused by human error in the manufacturing industry using Structural Equation Modelling (SEM). The objectives of this study are:

- (i) To study the factors measured by unsafe behaviour, safety knowledge and workplace environment.
- (ii) To determine the conceptual framework of the study.
- (iii) To investigate the relationship between human error to safety knowledge, unsafe behaviour and workplace environment.

1.5 Scope and Limitation of the Study

The scope of this study is to use Structural Equation Modelling to study the data obtained from the results of the questionnaire distributed to the workforce of the manufacturing industry. Another scope is to study the factors causing workplace accidents that are affected by human error. The final scope is to find out the operational definitions of human error, workplace accidents as well as the factors causing workplace errors due to human error.

Some of the limitations of this study are there are a limited number of variables as a mediator due to the constraints of this study. Next, the focus is placed only on unsafe behaviour, safety knowledge and workplace environment where other factors such as safety climate and safety culture are not studied. The results and data obtained are also only from the manufacturing industry and not from other industries such as the construction and chemical industry which limits the outcome of the project. Besides that, the demographic of the questionnaire is concentrated only in Malaysia and not in other countries. Another limitation is that the relationship between each of the independent variables, safety knowledge, workplace environment and human behaviour are not interrelated to each other, hence, this relation can be considered in future studies. The final limitation is the results obtained from the survey are self-reported and hence, there might be bias.

1.6 Contribution of the Study

Human error has long been the cause or partly responsible of some of the worse incidents in history leading to severe injuries or even death (Petrillo et al., 2017). The discovery of the relationship between safety knowledge, unsafe behaviour and workplace environment to human error can help lead to the decrease of workplace accidents in the manufacturing industry due to human error. In this way, even though there will always be human error in the manufacturing industry to a certain extent, the rate at which workplace accidents occur can be significantly decreased.

Through this study, researchers can further explore the relations between human error to safety knowledge, unsafe behaviour and workplace environment. Even though the relation between these independent variables have been explored in previous research independently or with other variables such as safety culture and safety performance, there has not been any research done that encompasses these three independent variables studied in this report.

Other than that, the manufacturing industry will benefit through this study because the occurrence of human error will decrease leading to less injuries to the worker which can increase the safety of the workers in the plant as well as reduce any costs that need to be beared by the plant due to the workers injuries. Lastly, through the data analysis performed in this study, future researchers will also continue to explore more factors behind workplace accidents in the manufacturing industry in order to further reduce the occurrence of human error.

1.7 Outline of the Report

Human error can be described as the process of learning how individuals interact, their strengths and limitations and the person’s pursuit in the ways of improving their task performances. Some of the causes of accidents may be due to lack of training and exhaustion, causing the workers to desire to accomplish their tasks as quick as possible without concern for their own or others’ safety (Mohammadfam et al, 2021). The purpose of this study is to investigate the causes of human error to reduce the occurrences of human error using Structural Equation Modelling in order to prevent and solve the causes of human error to reduce the possibility of the occurrence of human error in the manufacturing industry. This study is performed in order to find out the relationship between human error as the dependent variable to safety knowledge, unsafe behaviour and workplace environment as the independent variables. Due to constraints on the number of variables in the study, there are limitations in the number of variables where other variables such as safety clture are not studied and may be further explored as possible causes of human error in future studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of the literature review is to find out information that is similar and related to the scope of the study. This chapter focuses on workplace accidents as well as the reasons why they occur with emphasis on human error.

2.2 Domino Theory of Accident Causation

The Domino Theory was developed by Heinrich et al., 1980, which claims that all accidents happen due to a chain of events consisting of five factors which can be seen in Figure 2.1 which are ancestry and surrounding environment, due to the individual themselves, risky behaviour and/or physical hazard, the accident and resulting injury.

All of these stated factors act as the dominoes where the removal of any one of these will result in the prevention of the accident. Accidents happen due to various reasons and involves various types of accidents and injuries whether minor, serious or resulting in death. The Domino Theory can be separated into 2 categories where the first cause of accidents are humans who are the main basis for the occurrence of accidents and the second cause is management which are in charge of preventing the accidents due to their ability of having power and authority (Hosseinian, et al. 2012).

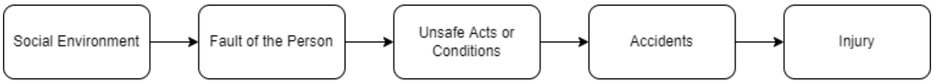


Figure 2.1: Domino Theory of Accident Causation

2.3 Workplace Accidents

According to Heinrich et al., 1980, an accident may be defined as events which have not been planned or are uncontrollable in which the action or reaction of an entity, medium, human or radiation results in injury to themselves, other persons or others. It can be found that, most of the methods of inspections of accidents are carried out by personal with little or limited experience in the analysis of human error or competent human causal factors (Haste, 2005).

The failure to discover the causes of workplace accidents results in the continuous occurrence of incidents whether largely impactful to the operation of the plants or not, affecting the on-time and cost-effective operations (Garrett et al., 2009). According to Ng et al., 2013, some of the causes of accidents are due to an insufficiency in being aware of the direction of torque, tactile perception, shape and size of an object which can cause finger injuries and disorders of the musculoskeletal. Work related accidents can be divided into 2 categories which are fatal and non-fatal accidents (Haatainen, 2010).

2.4 History and Development of Safety

In Malaysia, there are statutes established for the health, safety and welfare of the employees. One of these statutes is the Department of Occupational Safety and Health (DOSH), established in 1994, the purpose of this department is to enforce laws and conduct inspections on occupational safety and health as well as unsafe working conditions and practices. The department ensures that there is a written statement ensuring that workers have a health and safety policy which must be adhered to by the employee in proving their dedication to occupational health and safety. The safety policy ensures that each and every job-related classification has a safe work environment ensured by the management or employer.

Next, the Social Security Organisation (SOCSO) was established in 1971 under the Employees’ Social Security Act 1969 as part of the government department of Labour and Manpower. This organisation provides social security protection by social insurance to provide financial protection and guarantees in the case of accidental injuries or diseases related to their jobs. Besides that, Standard Operating Procedures (SOP) is a set of instructions or guidelines for workers to carry out routine operations and procedures in order to maximise the health and safety of the workers. The SOP can be established when the risks of the job scope have been properly identified where a safety manual will be drawn in order to state the concise safety policy, safety factors, liability of the workers and management (Ayob et al., 2018).

2.5 Human Error

According to Chi et al. 2015, human error can be characterised as the lack of proper judgement or appropriate decision-making characteristics in the cognitive process. Human error can be divided into 3 different categories which are skill-based, rule-based and knowledge-based errors based on the generic error modelling system (GEMS) by Reason (1990). Some of the human qualities that can cause complications in interactions with the workplace environment are such as consciousness, human perception, recollection ability, and rationality.

There may be many different elements in the workplace that may cause sensory overload due to the large amounts of information needed to be processed at a time and cause a person to lose focus especially in instances where repetitive behaviour is necessary. This may cause a person to perform their tasks by reflex actions which may cause error because their focus is not fully concentrated on their assigned tasks. Another quality is human perception which in needed to recognise and safely mitigate the risks and dangers in the workplace in order to reduce the probability of accidents happening not only for their own safety but also for the safety of their co-workers. The next quality is memory where all humans have a limited capacity for remembering and absorbing information where high pressure situations may put a further damper on a person's ability to be able to remember and perform normal tasks or in emergencies. The increase in knowledge and understanding of a task will help a person to preserve the information related to that particular task. The final quality is rationality which helps a person to be able to make good judgement calls in decision-making in especially unusual situations in order to make the necessary and corrective action to solve the problem (Kumar et al., 2008).

2.5.1 Causes and Effects of Disasters Caused by Human Error

There are many factors as to the causes of human error in accidents where some of the reasons are such as psychological, physiological, external environmental factors and also lack of safety training and management of the workers (WenWen et al., 2011).

Some of the largest and well-known accidents where human error was the cause, if not partially responsible for are such as Three Mile Island nuclear facility release and the Chernobyl nuclear plant disaster These accidents caused endangerment to not only the workers at the site but also to the health and safety of the public, where some of those ramifications are still felt today. According to Selmi et al., 2016, the cause of the Chernobyl disaster in 1986 was because of a flaw in the design of the nuclear reactor and under-trained personnel operating the reactor. The explosion of the reactor caused radioactive substances to be released into the environment for a period of about 10 days and later on, the residents in the surrounding areas were evacuated and have not been allowed to return to this day.

Whereas in the Three Mile Island nuclear facility, the cause was due to the plant operators being provided with inadequate and misleading information by the reactors measurement instruments and also overheating of the core due to assumptions made by the operators. These disasters caused there to be many psychological effects as well as demoralisation and lower occupational self-esteem which impacted the mental health of the nuclear workers (Mangano, 2004).

2.6 Factors Influencing Workplace Accidents

Some of the factors affecting the occurrence of human error is such as safety compliance, safety knowledge, safety culture, safety climate, safety knowledge, safety participation, unsafe behaviour, workplace environment. According to Griffin and Neal, 2000, safety participation can be defined as the conduct that may not have an immediate relation to workplace safety but helps in the development of an environment that encourages safety.

In addition to that, another type of safety is safety compliance that includes standards of safety, safety courses of action and safety systems of work which has an immediate effect on work and individuals performing the work (Martínez-Córcoles et al., 2011). Whereas safety participation is defined as the engagement of workers in the activities in the workplace such as safety conferences, safety trainings or the simple act of helping their colleagues at work with tasks which helps to promote a safe work environment (Pedersen and Kines, 2011).

Safety culture can be defined as an inquisitive theory and not a factual entity (Antonsen, 2009) where it is not an isolated concept but it the relationship between safety and culture (Nordlöf et al., 2015). Safety climate can next be defined as the similar views of employees regarding safety policies, courses of action and implementation in a company (Zohar, 2011) where shared views regarding the definition of safety has been proven to have an impact on various different industries that encounters individual and environmental hazards (Griffin and Curcuruto, 2016). Although there are many factors affecting the occurrence of workplace accidents, the other factors of safety knowledge, workplace environment and unsafe behaviours are studied in this report which will be further discussed later on.

2.7 Conceptual Framework

The conceptual framework is formed as shown in Figure 2.2 where the independent variable is human error and safety knowledge, unsafe behaviour and workplace environment are the dependant variables. In this study, the relationship between each of the dependant variables to the independent variables will be studied in order to find out the factors affecting human error that leads to the occurrence of workplace accidents in the manufacturing industry.

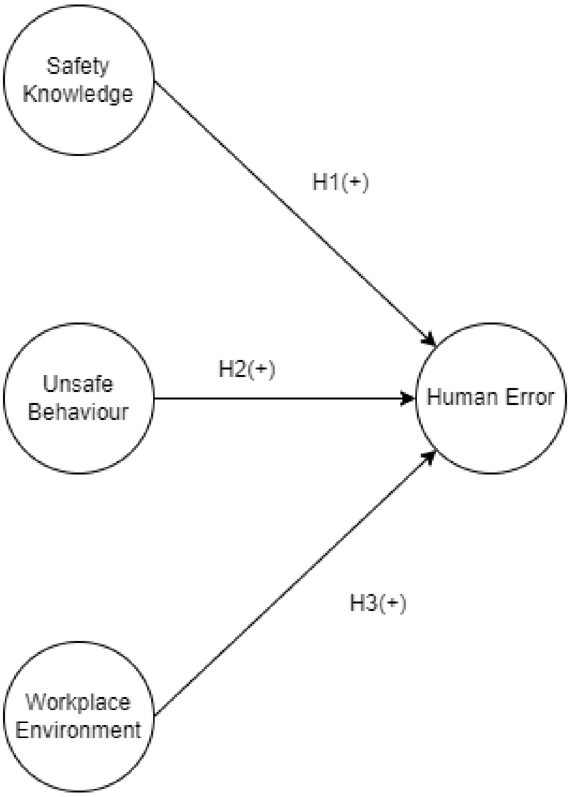


Figure 2.2 Conceptual framework

2.7.1 Safety Knowledge and Human Error

Safety knowledge is the ability of knowing the ways of performing work safely (Nykänen et al., 2020). Some of the forms of knowledge are the authorised safety rules and regulations, based on personal experience and workplace accident records where, the more safety knowledge a worker has, the less likely the risk of accidents. Safety knowledge can be enhanced by providing workers with safety training which prepares workers with the skills needed to recognise and manage workplace hazards. Workers must also have informal knowledge of industrial profession such as the rules of thumb and skills so that they are well equipped with the knowledge that can be obtained through observation and first-hand experience. (Memon et al., 2020).

H1: There is a significant relationship between safety knowledge and human error

2.7.2 Unsafe Behaviour and Human Error

In 1931, it was first proposed by Heinrich in the study of Industrial Accident Prevention that the direct cause of an accident can be related to unsafe behaviours which was then further supported by Zabetakis (1967); Lawrence (1974); Hale and Hale (1970); Stewart (2013) and Reason (1990) who had the opinion that human error or unsafe behaviour is the direct cause of accidents. The susceptibility of a person to accidents can be used to suggest that some individuals have a higher accident-related quality as compared to others (Farmer and Chambers, 1929; Greenwood and Woods, 1919).

Since the 1960s, many accident investigations have been carried out in order to find out the causes of on-site accidents where in 2005, Hasham et al. carried out a study on 100 accidents and found out that 49% of accidents were caused by workers' unsafe behaviour. In addition to that, in 2001, Suraji examined 500 reports on accidents and found out that 29.9% of accidents involved inappropriate operative actions and 88% were due to inappropriate operation which can be categorised under workers' unsafe behaviour.

Based on the Heinrich's domino theory, the accidents' direct causes is unsafe human behaviour and unsafe object condition (Heinrich et al.1950). The understanding and study of unsafe behaviour can help ensure that workers and managers alike can be prepared with the appropriate and adequate tools in order to reduce unsafe behaviour and reduce the occurrences of on-site accidents (DongpingA, et al. 2016). Besides that, unsafe behaviour can be linked to human error or inappropriate human decision, this leads to the reduction of safety during operations and cause accidents, injuries and affect the normal schedule of production and projects in the workplace (Abreeu Saurin et al., 2005; Aksorn & Hadikusumo, 2008; Teo et al., 2005; Choudhry & Fang, 2008).

H2: There is a significant relationship between unsafe behaviour and human error.

2.7.3 Workplace Environment and Human Error

The basic qualities of a reasonable work environment are such as normal surrounding temperature, odourless, uncongested, dustless and peaceful conditions (McGarth, 1978). The lack of appropriate work conditions may lead to a decrease in morale, causing job dissatisfaction as well as stress to the workers that may also be caused by lost of concentration which will decrease the performance of the company itself (Yeow et al., 2012). The poor working conditions in the workplace may also lead to an increase in the rate of accidents which may affect the income of the company. Some examples of poor working condition are such as vibrations of the machines and noise above the margin of safety as well as lack of appropriate lighting that may cause headache and strains to the workers field of vision as well as insufficient protection such as lack of Personal Protection Equipment (PPE) for example hard hats and protective glasses from physical, chemical and other various hazards that will protect the wearer’s body from harm and injury (Yeow, 2014).

H3: There is a significant relationship between workplace environment and human error.

2.8 Occupational Health and Safety Act (OSHA)

The Occupational Health and Safety Act (OSHA) was first introduced in 1994 as a judicial framework to defend the safety, health and welfare of all Malaysian workforces and to protect against the risks to a worker's safety or health related to activities performed at work.

The other objectives of this act are to protect a person at their place of work besides persons at work against endangerment to safety of health due to the activities of that person at their place of work. Other than that, the purpose of OSHA is also to encourage a job-related environment for individuals at work that is modified according to their physiological as well as their psychological needs. Lastly, OSHA is to prepare the necessary means where there can be a gradual replacement of the appropriate occupational health and safety legislations to an alternative and new system of rulings and codes of industrial practices that have been approved that utilises the resources of this Act in order to provide a betterment of the standards or safety and health (The Commissioner of Law Revision, 2006).

2.9 Summary

In this chapter, the factors influencing the workplace accidents which are caused by human error is discussed and compared and the final three factors that are most suitable to be researched is safety knowledge, workplace environment and unsafe behaviour. The factors influencing the workplace accidents must be properly researched and studied in order to decrease the occurrence of accidents in order to decrease the risk of harm and danger from occurring to workers especially in dangerous work environments. Even though the occurrence of workplace accidents cannot be fully eliminated as it is normal human nature to make mistakes. However, through this report, the factors affecting workplace accidents can be studied from a different perspective and give a deeper insight in order to further lower and improve the accident statistic data in Malaysia.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

The contents of this chapter are about the results obtained from the methodology as well as the work plan of the project. The literature review analysed in the previous chapter will be used to identify the critical factors affecting workplace accidents due to human error. The flow chart of the steps performed in this project are shown in Figure 3.1.

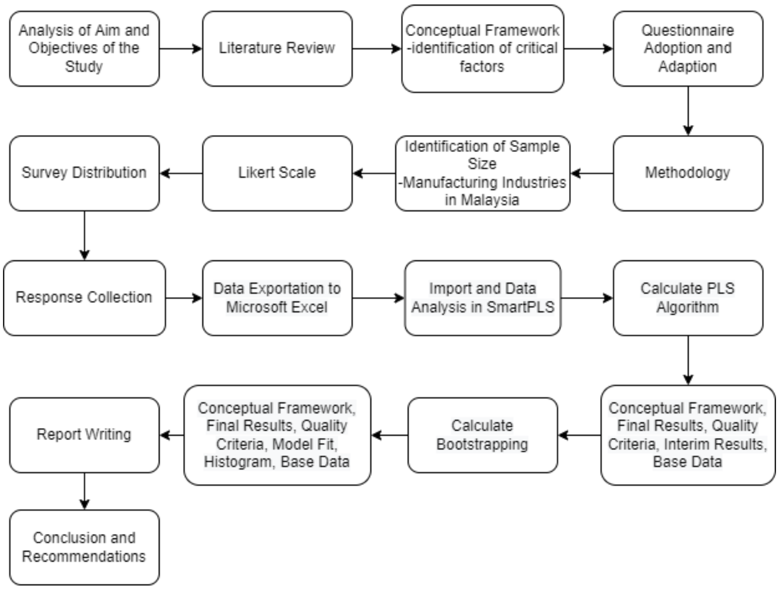


Figure 3.1 Flow Chart of the Steps Performed

3.2 Research Location

The location of the research study is in Malaysia and more specifically the manufacturing industry. Based on the Department of Statistics Malaysia, 2021, based on the occupational accident data provided by the Department of Occupational Safety and Health (DOSH) and Social Security Organisation (SOCSO), Ministry of Human Resources, the manufacturing industry is one of the industries that has the highest rates of accidents occurring as compared to other industries. Hence, it is important for the field of study to be focused on the manufacturing industry in order to decrease the rate of injuries and fatalities to workers.

3.3 Likert Scale

The Likert scale was first introduced in the 1930s by Rensis Likert in order to measure a sequence of theories related to attitude or opinion of people (Likert, 1932). This scale is used in various industries as an indicator to evaluate the workplace performance of employees or even in fields such as marketing and psychometric research. In this study, the 5-point Likert scale will be used in ascending order from being in strong disagreement to strong agreement of the statement is Strongly Disagree, Disagree, Neutral, Agree and finally Strongly Agree. The neutral point provides an option to the respondents where they are not forced to disagree or agree with the given opinion and is important to be used when statistical analysis is performed which is being investigated in this study. (Chyung, 2017).

3.4 Pilot Test

A pilot test can be performed which can be described as a small study performed in order to examine investigation protocols, instruments of data gathering, strategies of sample collection and other various techniques in research to construct a larger study. This test is carried out in order to evaluate the validity of the measuring instrument, such as a questionnaire. This is done to assess the comprehensibility and appropriateness of the questionnaire in order to ensure that the items listed in the questionnaire precisely address the research question (Hassan et al, 2006). In this test, the questionnaire may first be sent out to 12-20 companies to obtain feedback. If the questionnaire is proven to be valid from the obtained responses, the questionnaire will then be sent out to another 70-100 companies to prove the validity and reliability of the study.

3.5. Effect Size

An effect size e (Cohen, 1988; 1992; Kock, 2014b) is a measure of an effect's magnitude that is independent of the sample size analysed. In PLS-SEM, two basic measurements of effect size are widely utilised. One of the measurements is Cohen's f coefficient (Cohen, 1988; 1992) is derived as $\Delta R^2 / (1 - R^2)$ where the definition of R^2 is as a predictor of the latent variable to which it points. The absolute contribution of the predictor latent variable (Kock, 2014b;

Mandal et al., 2012) essentially the numerator ΔR^2 of Cohen's f^2 without the denominator correction is another measure of effect size that is widely employed in PLS-SEM (Kock, 2014b; Mandal et al., 2012). This second metric tends to produce lower results, making it a more conservative estimate of effect magnitude. The effect sizes of 0.02, 0.15 and 0.35 are referred to as small, medium and finally, the large size (Cohen, 1992; Kock, 2014b).

3.6 Validity and Reliability

3.6.1 Structural Equation Modelling (SEM)

Structural equation modelling (SEM) is the method of analysing data that is commonly used in market research due to its capability of testing additive and linear causal models that have been conceptually supported (Haenlein, & Kaplan, 2004; Statsoft, 2013; Chin, 1996). Through the usage of SEM, it enables marketers to study the correlation between the subjects of interest in order to identify the vital resources needed to improve customer service. In a structural equation model, two sub-models can be found where one is the inner model which is the correlation between the independent and the dependant variable whereas the outer model is the relation between the underlying variables and their measured indicators where the variable will either be an endogenous or an exogenous variable (Wong, 2013).

3.6.2 Covariance-Based Structural Equation Modelling (CB-SEM)

CB-SEM is one of the approaches in SEM which is used in the confirmation or rejection of a conjecture through the use of hypothesis testing especially if there is a large sample size, normally distribute data and a correctly defined hypothesis where the variables in the model are connected in order to transform a theory into a structural equation model (Reinartz et al., 2009; Hwang et al., 2010). However, in this research paper, the method of PLS-SEM is used instead of CB-SEM due to the fact that it is difficult to find an exact data set that can meet these conditions as well as a limited knowledge is known about the relation between the variables due to the experimental research objective (Wong, 2013).

3.6.3 Partial Least Squares Structural Equation Modelling (PLS-SEM)

In the PLS-SEM approach, there are no inferences made about the distribution of data where it is more advantageous to use PLS-SEM in this research where the data distribution is skewed due to the fact that the survey is focused on the manufacturing industry only in Malaysia instead of in other countries or in other types of industries (Wong, 2010). Besides that, PLS-SEM is also used due to its predictive accuracy and also because the correct model specification in this study is not guaranteed only hypothesis are made about the independent and the dependant variables. Another reason is because PLS-SEM is more appropriate to be used when there are only a few variables or sample sizes to be studied where in this case, there are 3 independent variables which are safety knowledge, unsafe behaviour and workplace environment and 1 dependent variable which is human error (Hwang et al., 2010, Wong, 2010).

3.6.4 G*Power Analysis

G*Power analysis is used in this study with the use of the f-test, linear multiple regression of fixed model and a priori power analysis in order to compute the required sample size given the α, power and effect size. For the statistical test, linear multiple regression is selected because it is used to approximate the relationship between the changes of the dependant variable with the independent variables. In this test, the relationship between one dependent variable and two or more independent variables are determined which in this study is human error for the dependent variable and safety knowledge, unsafe behaviour and workplace environment for the independent variable (Bevans, 2020).

An a-priori analysis is used in this study to determine the sample size and is carried out before the study is performed. This is also used to determine the desired α alpha probability, the power level of $(1-\beta)$ as well as the effect size. It can also be used to prove the hypothesis where there are 3 hypotheses to be proven in this study (Serdar, C. C., Cihan, M., Yücel, D., & Serdar, M. A. (2021).

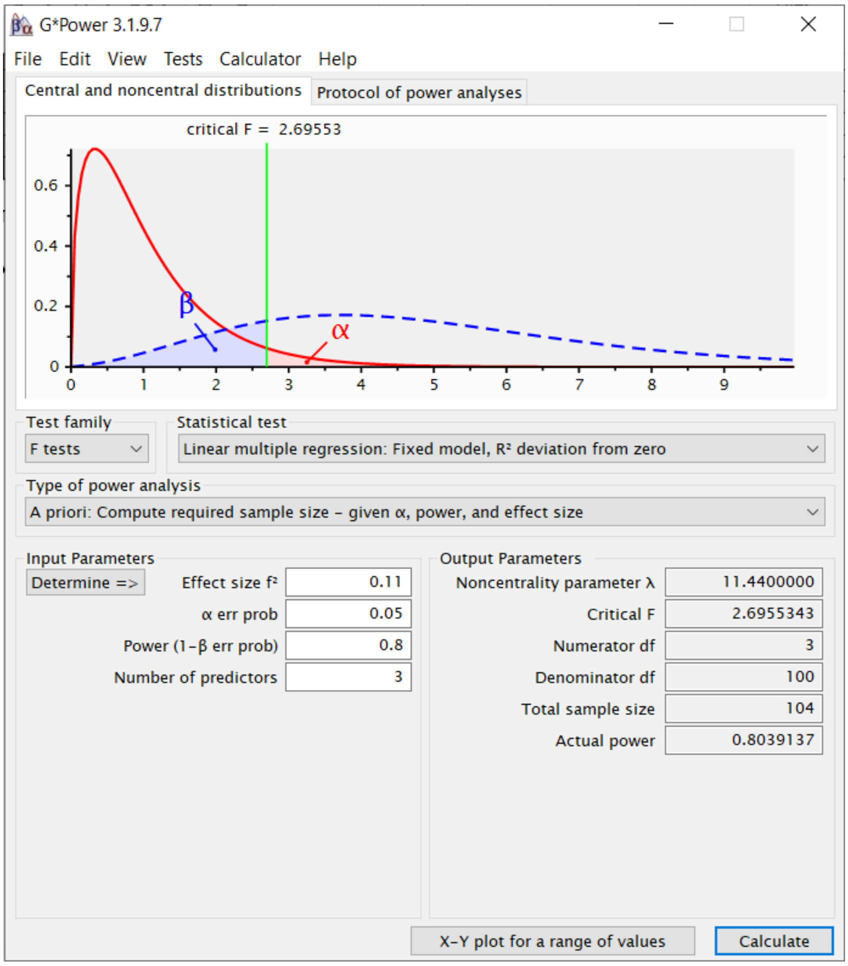
The input parameters are set with an effect size, f^2 of 0.11 which indicates a medium effect of the relationship between the variables, α error probability of 0.05 and power (1-β) error probability of 0.80. Since there are 3 independent variables which are safety knowledge, unsafe behaviour and workplace environment in this study, the number of predictors is set at 3. Hence, from the output parameters in Figure 3.2, the minimum sample size is found to be 104 participants after calculations using the G*Power software and actual power of 0.8039. However, the survey will be distributed to about 1600 participants in order to be able to collect as much data as possible.

$$\begin{aligned} Since\ f^2 &= \frac{R^2}{1-R^2} \\ &= \frac{0.10}{1-0.10} \\ &= 0.11 \end{aligned} \tag{3.1}$$

where,

f^2 = effect size

R^2 = predictor of the latent variable



Test family: F tests

Statistical test: Linear multiple regression: Fixed model, R^2 deviation from zero

Type of power analysis: A priori: Compute required sample size – given α, power, and effect size

Input Parameters	
Effect size f^2	0.11
α err prob	0.05
Power (1–β err prob)	0.8
Number of predictors	3

Output Parameters	
Noncentrality parameter λ	11.4400000
Critical F	2.6955343
Numerator df	3
Denominator df	100
Total sample size	104
Actual power	0.8039137

Figure 3.2: G*Power analysis

3.6.5 Inverse Square Root Method

When PLS-SEM is used to study samples from a certain population, each analysis will yield different path coefficients. A standard error (S) will be assigned to each route coefficient (*β*). When the distribution of the ratio *β/S* is plotted while additionally identifying the position of the critical T ratio (Kock, 2015; Weakliem, 2016) for a given significance level, a bell-shaped graph will be observed.

The impact associated with the route coefficient will be accurately deemed statistically significant for each instant when the ratio *β/S* exceeds the critical T ratio. The assumptions that the route coefficient is referring to a "true" effect that occurs at the population level.

Increases in the path coefficient magnitude and decreases in the standard error *S* increases the magnitude of the ratio *β/S*. The standard error also lowers as the sample size grows. As the magnitude of the path coefficient and the size of the sample size evaluated grows, the likelihood that the ratio *β/S* will exceed the critical T ratio grows. As a result, the chances of an effect that does exist at the population level being wrongly dismissed is reduced. In other words, the test's power will improve (Kock, N. & Hadaya, P., 2018).

Assuming,
Power level = 0.8 and
$\text{Significance level} = 5\%$

$$n_{min} > \left(\frac{2.486}{|p_{min}|}\right)^2$$

Taking 0.11-0.2

$$= 5\%: n_{min} > \left(\frac{2.486}{|1-0.8|}\right)^2 \tag{3.2}$$

$$= 155$$

Sample size = 155

where
p_{min} = minimum power
n_{min} = significance level

3.6.6 10-Times Rule Method

The 10-Times Rule approach is the most extensively used minimum sample size estimate method in PLS-SEM, in the field of information systems as well as in other fields (Hair et al., 2011; Peng & Lai, 2012). The most prevalent form of this strategy is one that is based on the premise that the sample size should be at least 10 times larger than the maximum number of inner or outer model linkages pointing to any model's latent variable (Goodhue et al., 2012).

This method does not rely on the magnitude of the path coefficients but leads to a minimum sample size estimation of 20 in the journal of MIS Quarterly in 2005 (Majchrzak et al., 2005) regardless of the strengths of the path coefficients. This is due to the fact that the maximum number of links in the model pointing to any variable in the model is 2 which when multiplied by 10 equals to 20. However, this method caused widely erroneous estimates of the minimal size necessary (Kock, N. & Hadaya, P., 2018).

$$\begin{aligned}\text{Sample size} &= 10 \times \text{number of model links pointing at any variable} \\ &= 10 \times 3 \\ &= 30\end{aligned} \tag{3.3}$$

3.6.7 Minimum R-Squared Method

The minimum R-Squared method approach as in Table 3.3 (Hair et al., 2014) proposed an alternative to the 10-times rule method for estimating the minimum sample size which is referred by this name because of the use of minimum R^2 is frequently used in the estimation for the minimum sample size. The estimation of sample size using Cohen's power tables for the least-squares regression is based on a table that lists the minimal sample sizes necessary based on three elements.

The highest number of arrows that point at a construct in a model is considered as the first element. Next is the significance level and the third element is the model's minimum R^2. The significance level that is focused on in this version is 0.05 with an assumed power of 0.8. This method is considered to be an improvement as compared to the 10-times rule method since it required at least one more input outside of the model's network of linkages.

However, this method can also cause widely erroneous estimates of the minimal size necessary (Kock, N. & Hadaya, P., 2018).

Significance level = 0.05, Power = 0.80

Table 3.1: Minimum R-squared method

Maximum number of arrows pointing at a construct	**Minimum R^2 in the model**			
	0.10	**0.25**	**0.50**	**0.75**
2	110	52	33	26
3	124	59	38	30
4	137	65	42	33
5	147	70	45	36
6	157	75	48	39
7	166	80	51	41
8	174	84	54	44
9	181	88	57	46
10	189	91	59	48

Using the minimum R^2 method, with 3 independent variables
With minimum R^2 as 0.10, the sample size = 124

Table 3.2: Summary of minimum sample size determination methods

Method	**Sample Size**
Inverse Square Root Method	155
Minimum R squared method	124
G*Power	104
10-times rule method	30

By comparing the methods to obtain the minimum sample size in Table 3.4, G*Power analysis is taken as the most reliable method and hence, the sample size is taken as 104.

3.7 Cochrane Systemic Review

Another method of analysis is the Cochrane systemic review which is normally used in randomised trials in order to decrease the chances of there being a bias in the study however the risk of bias cannot fully be eliminated (Cates, 2014) where there could be a bias in only reporting good results due to its primary use in the medical field.

3.8 One-Way Analysis of Variance (ANOVA)

The analysis of variance (ANOVA) is a method of using statistics to approximate the means of various populations which are assumed to have a normal distribution. From this, the One-Way analysis of variance (ANOVA) which is a supplement of the two-sample t-test in an which is used to approximate the power of two types of hypotheses. This is used in order to make a comparison between the means of various groups, overall test and contradicting specifications (Mahapoonyanont, 2010).

3.9 Data Analysis

3.9.1 Normality

For the PLS-SEM approach it has the ability to estimate the path values for various sample sizes. The distributional assumption made in the PLS-SEM approach is that the normality of the data is not met. When compared to CB-SEM, at smaller sample sizes, the path values are not able to be estimated and the median is centred at zero whereas, PLS-SEM can estimate the path values accurately. As the sample size increases, PLS-SEM is able to be consistent and measure the coefficient of the paths at various sample sizes. This approach is also able to approximate the path when under non-normal conditions as well as have a smaller confidence interval for various sizes of samples (Wong, 2013).

3.9.2 Validity

The validity of the hypothesis will be performed after the data is collected through the distribution of questionnaires which will be distributed to workers in the manufacturing industry to if the hypothesis is true about the factors affecting the occurrence of workplace accidents due to human error. PLS-SEM will be used to run the analysis in order to identify the statistics of the data obtained and to justify the relationship between the safety knowledge, workplace accidents and unsafe behaviour to human error.

3.10 Summary

In conclusion, the methodology and workplan are discussed in this chapter. Due to the size of the sample used as well as to reduce the risk of bias in the results, the G-Power analysis and PLS-SEM will be used. For the research location, the questionnaires will be distributed to the workforce of the manufacturing industry in Malaysia. The assumptions made in the data analysis will be that the normality of the data has not been met and the validity will be confirmed through the analysis of PLS-SEM from the results obtained through the distribution of the questionnaire in order to justify the relationship between safety knowledge, workplace environment, unsafe behavior and human error. Lastly, the 5-point Likert Scale will be used in the questionnaire where the five points are Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree (Likert, 1932).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The reliability and validity of the results obtained through the surveys distributed to the respondents is performed in SmartPLS through the calculation of the PLS Algorithm and Bootstrapping. The structural model assessment is then performed in order to evaluate and examine the results obtained.

4.2 Respondents Demographic Profile

The total number of respondents obtained through the distribution of the survey is 117 respondents from various states in Malaysia, company sizes, type of businesses and positions in the company. The summary of the demographic profile of the respondents are shown in Table 4.1.

The highest percentage of manufacturing companies are located in Penang with 50 respondents composing of 42.7% of the total respondents and Selangor with 32 respondents composing of 27.4% of the total respondents. Other than that, the highest percentage of the business size of the companies are large scare companies with the number of full-time employees being more than 200 with 61 respondents and 52.1%. Besides that, the highest type of industry is the electrical and electronics industry composing of 49 respondents with 41.9%. Lastly, the highest percentage of the position of the respondents is as an Engineer with 41 respondents and 35.0%.

Table 4.1: Demographic Profile of the Respondents

Company Location	**Frequency**	**Percentage (%)**
Johor	9	7.7
Kedah	5	4.3
Kelantan	0	0
Melaka	2	1.7
Negeri Sembilan	5	4.3
Pahang	2	1.7
Pulau Pinang	50	42.7
Perak	7	6.0
Perlis	0	0
Sabah	0	0
Sarawak	2	1.7
Terengganu	0	0
Selangor	32	27.4
Kuala Lumpur	3	2.6
Labuan	0	0
Putrajaya	0	0
Company Business Size		
Small Enterprise (Number of full-time employees below 75)	32	27.4
Medium Enterprise (Number of full-time employees between 75 - 200)	24	20.5
Large Scale Company (Number of full-time employees more than 200)	61	52.1
Type of Industries		
Automotive Industry	4	3.4
Chemical Industry	4	3.4
Electrical and Electronics Industry	49	41.9
Food and Beverage Industry	11	9.4

Machinery and Equipment Industry	7	6.0
Metal Industry	7	6.0
Oil and Gas Industry	2	1.7
Plastics Industry	5	4.3
Rubber Industry	5	4.3
Others	23	19.6
Position in the Company		
Technician	6	5.1
Executive	10	8.5
Operator	6	5.1
Engineer	41	35.0
Supervisor	12	10.3
Manager	32	27.4
Specialist	1	0.9
Others	9	7.7

4.3 Internal Consistency

According to Table 4.2, the values of Cronbach's Alpha, rho_A, Composite Reliability and Average Variance Extracted (AVE) can be observed.

Otther than that, based on Cortina, J.M., 1993, the value of Cronbach's Alpha should be above 0.7. Hence, the values obtained obtained for HE, SK, UB and WE are 0.911, 0.742, 0.907 and 0.887 respectively, the items have satisfactory values of Cronbach's Alpha.

Next, for the values of Dijkstra-Henseler's rho or rho_A, the values should be above 0.7. Hence for the values obtained which are 0.916, 0.808, 0.910 and 0.893 for HE, SK, UB and WE respectively, the rho_A is satisfactory

The internal consistency is said to be reliable when each of the constructs have a Composite Reliability of more than 0.5. Hence, since HE, SK, UB and WE have Composite Reliability values of 0.933, 0.882, 0.931 and 0.917, the items have an satisfactory internal consistency reliability.

The internal consistency is significant when the values of the Average Variance Extracted (AVE) is more than 0.50. Therefore, since the values of the

AVE obtained for HE, SK, UB and WE are 0.737, 0.790, 0.730 and 0.688, there is an establishment of the internal consistency.

Table 4.2: Matrix of Construct Reliability and Validity of PLS Algorithm

	Cronbach's Alpha	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Human Error	**0.911**	**0.916**	**0.933**	**0.737**
Safety Knowledge	**0.742**	**0.808**	**0.882**	**0.790**
Unsafe Behaviour	**0.907**	**0.910**	**0.931**	**0.730**
Workplace Environment	**0.887**	**0.893**	**0.917**	**0.688**

4.3.1 Cronbach’s Alpha

The T values in Table 4.3 are above 1.96 and are ranging from 11.985 to 56.059 and the P values for all the constructs are 0.000 which are below 0.05. Hence, the results of Cronbach’s Alpha are significant. All of the 2.5% of the cases in Table 4.4 lie above the upper confidence limit with values of 0.874, 0.597, 0.856 and 0.836, hence, the confidence limits are 97.5%. Since there is no 0 in the bias corrected 97.5% confidence limits in Table 4.5 with values of 0.936, 0.843, 0.936 and 0.920, the Cronbach’s Alpha is significant (Garson, G.D., 2016).

Table 4.3: Mean, STDEV, T-Values, P-Values of Cronbach’s Alpha of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Human Error	0.911	0.909	0.016	56.059	**0.000**
Safety Knowledge	0.742	0.731	0.062	11.985	**0.000**
Unsafe Behaviour	0.907	0.902	0.022	40.773	**0.000**
Workplace Environment	0.887	0.883	0.022	39.767	**0.000**

Table 4.4: Confidence Intervals of Cronbach’s Alpha of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Human Error	0.911	0.909	0.874	0.936
Safety Knowledge	0.742	0.731	0.597	0.832
Unsafe Behaviour	0.907	0.902	0.856	0.935
Workplace Environment	0.887	0.883	0.836	0.919

Table 4.5: Confidence Intervals Bias Corrected of Cronbach's Alpha of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Human Error	0.911	0.909	-0.002	0.874	0.936
Safety Knowledge	0.742	0.731	-0.011	0.604	0.843
Unsafe Behaviour	0.907	0.902	-0.005	0.861	0.936
Workplace Environment	0.887	0.883	-0.004	0.840	0.920

4.3.2 rho_A

According to Table 4.6, the T values are above 1.96 and are ranging from 2.930 to 60.619 and the P values for all the constructs are 0.000 to 0.004 which are below 0.05. Hence, the results of rho_A are significant. Besides that, from Table 4.7, all of the 2.5% of the cases lie above the upper confidence limit with values of 0.883, 0.673, 0.863 and 0.849 hence, the confidence limits are 97.5%. Since in Table 4.8 there is no 0 in the 97.5% bias corrected confidence limits with values of 0.939, 0.998, 0.939 and 0.928, the rho_A is significant (Garson, G.D., 2016).

Table 4.6: Mean, STDEV, T-Values, P-Values of rho_A of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Human Error	0.916	0.916	0.015	60.619	**0.000**
Safety Knowledge	0.809	0.855	0.276	2.930	**0.004**
Unsafe Behaviour	0.910	0.909	0.021	42.834	**0.000**
Workplace Environment	0.893	0.899	0.025	35.573	**0.000**

Table 4.7: Confidence Intervals of rho_A of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Human Error	0.916	0.916	0.883	0.941
Safety Knowledge	0.809	0.855	0.673	1.253
Unsafe Behaviour	0.910	0.909	0.863	0.940
Workplace Environment	0.893	0.899	0.849	0.939

Table 4.8: Confidence Intervals Bias Corrected of rho_A of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Human Error	0.916	0.916	0.000	0.880	0.939
Safety Knowledge	0.809	0.855	0.046	0.600	0.998
Unsafe Behaviour	0.910	0.909	-0.001	0.857	0.939
Workplace Environment	0.893	0.899	0.006	0.827	0.928

4.3.3 Composite Reliability

From Table 4.9, the T values are above 1.96 and are ranging from 31.332 to 83.204 and the P values for all the constructs are 0.000 which are below 0.05. Hence, the results of Composite Reliability are significant. In Table 4.10, all of the 2.5% of the cases lie above the upper confidence limit with values of 0.909, 0.812, 0.897 and 0.939, hence, the confidence limits are 97.5%. Since in Table 4.11 there is no 0 in the 97.5% bias corrected confidence limits with values of 0.952, 0.929, 0.951 and 0.940, the Composite Reliability is significant (Garson, G.D., 2016).

Table 4.9: Mean, STDEV, T-Values, P-Values of Composite Reliability of Bootstrapping

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Human Error	0.933	0.932	0.011	83.204	**0.000**
Safety Knowledge	0.882	0.876	0.028	31.332	**0.000**
Unsafe Behaviour	0.931	0.928	0.015	62.649	**0.000**
Workplace Environment	0.917	0.914	0.015	60.644	**0.000**

Table 4.10: Confidence Intervals of Composite Reliability of Bootstrapping

	Original Sample (O)	Sample Mean (M)	2.5%	97.5%
Human Error	0.933	0.932	0.909	0.952
Safety Knowledge	0.882	0.876	0.812	0.922
Unsafe Behaviour	0.931	0.928	0.897	0.951
Workplace Environment	0.917	0.914	0.884	0.939

Table 4.11: Confidence Intervals Bias Corrected of Composite Reliability of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Human Error	0.933	0.932	-0.001	0.909	0.952
Safety Knowledge	0.882	0.876	-0.006	0.820	0.929
Unsafe Behaviour	0.931	0.928	-0.003	0.900	0.951
Workplace Environment	0.917	0.914	-0.003	0.886	0.940

4.4 Convergent Validity

The structural model that indicates the relationship of Safety Knowledge, Unsafe Behaviour and Workplace Environment to Human Error for PLS Algorithm and Bootstrapping can be seen in Figure 4.1 and Figure 4.2 respectively.

The values of the loadings for each latent construct which are Human Error (HE), Safety Knowledge (SK), Unsafe Behaviour (UB), Workplace Environment (WE) are not measured directly. For each latent construct, questions are formed in the questionnaire where each question is considered to be the observed variables or items such as SK1, SK2 and so on. The latent constructs are then observed through each of the questions. Using SmartPLS, the measurement and structural models can be assessed at the same time.

Since the values of the loadings for each of the items are more than 0.5, with a range of 0.778 to 0.929, they are considered to be reliable (Hair et al., 2010). Other than that, since there are positive values for the values of the loadings between the independent and the dependent variables, that is more than 0, it can be concluded that there is a positive relationship between the Safety Knowledge, Unsafe Behaviour and Workplace Environment to Human Error.

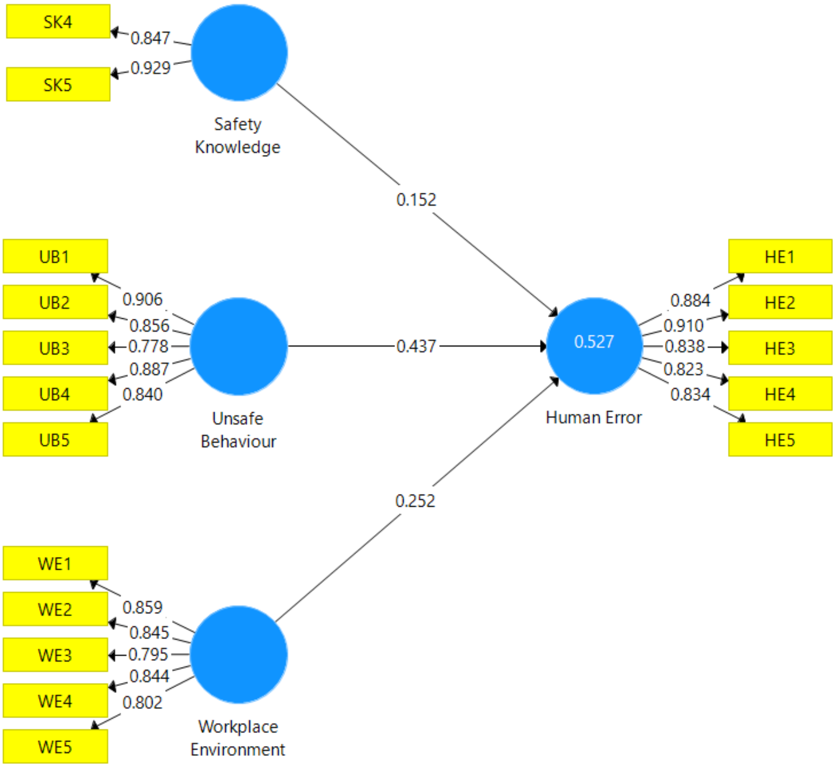


Figure 4.1: PLS Algorithm Structural Model

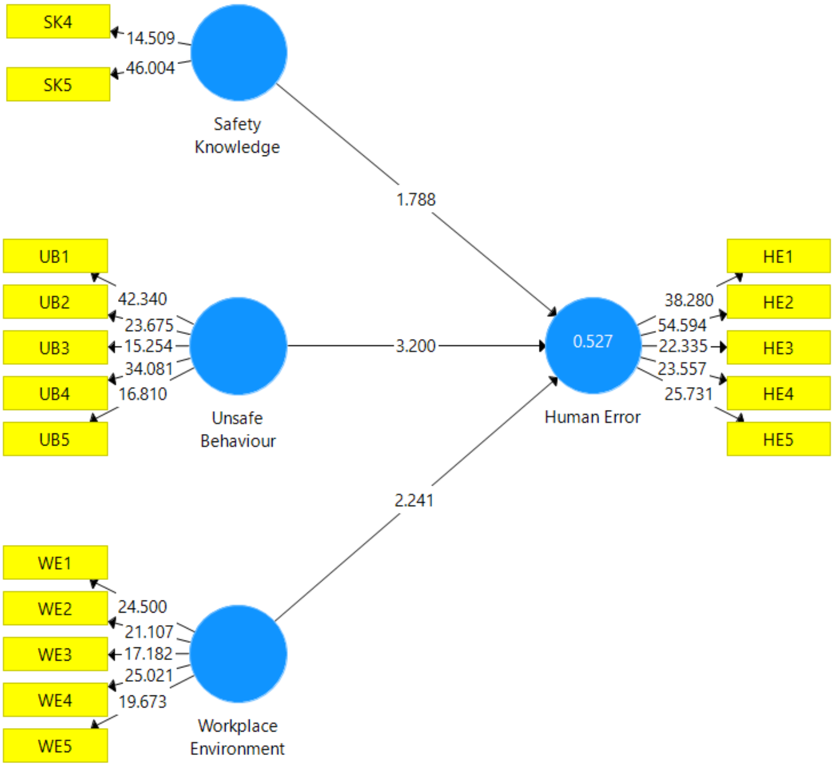


Figure 4.2: Bootstrapping Structural Model

4.4.1 Average Variance Extracted (AVE)

From Table 4.12, the T values are above 1.96 and are ranging from 16.753 to 21.593 and the P values for all the constructs are 0.000 which are below 0.05. Hence, the results of AVE are significant. From Table 4.13. all of the 2.5% of the cases lie above the upper confidence limit with values of 0.666, 0.688, 0.636 and 0.605 hence, the confidence limits are 97.5%. Since there is no 0 in the 97.5% bias corrected confidence limits in Table 4.14 with values of 0.798, 0.862, 0.797 and 0.759, the AVE is significant (Garson, G.D., 2016).

Table 4.12: Mean, STDEV, T-Values, P-Values of Average Variance Extracted (AVE) of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Human Error	0.737	0.735	0.034	21.593	**0.000**
Safety Knowledge	0.790	0.782	0.043	18.386	**0.000**
Unsafe Behaviour	0.730	0.724	0.043	17.091	**0.000**
Workplace Environment	0.688	0.683	0.041	16.753	**0.000**

Table 4.13: Confidence Intervals of Average Variance Extracted (AVE) of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Human Error	0.737	0.735	0.666	0.798
Safety Knowledge	0.790	0.782	0.688	0.855
Unsafe Behaviour	0.730	0.724	0.636	0.795
Workplace Environment	0.688	0.683	0.605	0.756

Table 4.14: Confidence Intervals Bias Corrected of Average Variance Extracted (AVE) of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Human Error	0.737	0.735	-0.002	0.666	0.798
Safety Knowledge	0.790	0.782	-0.008	0.699	0.862
Unsafe Behaviour	0.730	0.724	-0.006	0.647	0.797
Workplace Environment	0.688	0.683	-0.005	0.607	0.759

4.5 Discriminant Validity

4.5.1 Fornell-Larcker Criterion

Based on the Fornell-Larcker Criterion, there is a satisfactory discriminant validity if the loading on each of the construct is the highest on its own associated construct as compared to the loadings on the other constructs (Hair et.al, 2014). Hence, from Table 4.15, for example for SK to SK the loading is 0.889 as compared to SK to UB of 0.520. Therefore, the discriminant validity is established for all of the constructs.

Table 4.15: Fornell-Larcker Criterion of PLS Algorithm

	Human Error	**Safety Knowledge**	**Unsafe Behaviour**	**Workplace Environment**
Human Error	0.858			
Safety Knowledge	0.503	0.889		
Unsafe Behaviour	0.679	0.520	0.855	
Workplace Environment	0.608	0.491	0.644	0.829

4.5.2 Cross Loadings

The values of the loadings for the parent construct should be higher as compared to other constructs in the study. From Table 4.16, for example HE to HE1 has a value of 0.884 which is higher than SK to HE1 which is 0.458. If the loading on the parent construct is lower than the loading onto another construct, the discriminant validity has not been established well. Lastly, if the difference in the loadings between the parent construct and the other constructs is higher than 0.10 for example, the difference between HE to HE1 and SK to HE1 is 0.426, the discriminant validity is established, Hence, from all the observed loading values, there is an establishment of the discriminant validity (Garson, G.D., 2016).

Table 4.16: Cross Loadings of PLS Algorithm

	Human Error	**Safety Knowledge**	**Unsafe Behaviour**	**Workplace Environment**
HE1	0.884	0.458	0.575	0.646
HE2	0.910	0.480	0.630	0.551
HE3	0.838	0.418	0.664	0.453
HE4	0.823	0.447	0.526	0.460
HE5	0.834	0.345	0.508	0.484
SK4	0.359	0.847	0.411	0.344
SK5	0.514	0.929	0.504	0.506
UB1	0.586	0.439	0.906	0.603
UB2	0.593	0.507	0.856	0.519
UB3	0.516	0.357	0.778	0.440
UB4	0.578	0.451	0.887	0.590
UB5	0.619	0.459	0.840	0.587
WE1	0.567	0.483	0.633	0.859
WE2	0.540	0.401	0.485	0.845
WE3	0.429	0.293	0.448	0.795
WE4	0.487	0.394	0.479	0.844
WE5	0.482	0.444	0.611	0.802

4.5.3 Heterotrait-Monotrait Ratio (HTMT)

According to Clark and Watson, 1995, and Kline, 2011, the threshold values of the HTMT should be below 0.85. Since from Table 4.17, the values of HTMT obtained ranges from 0.582 to 0.743, there is an establishment of the validity of HTMT. In Table 4.18 all of the 2.5% of the cases lie above the upper confidence limit with values of 0.351, 0.520, 0.359, 0.480, 0.334 and 0.500 hence, the confidence limits are 97.5%. Since in Table 4.19 there is no 0 in the 97.5% bias corrected confidence limits with values of 0.797, 0.911, 0.840, 0.819, 0.799 and 0.867 the HTMT is significant (Garson, G.D., 2016).

Table 4.17: Matrix of Heterotrait-Monotrait Ratio (HTMT) of PLS Algorithm

	Human Error	**Safety Knowledge**	**Unsafe Behaviour**	**Workplace Environment**
Human Error				
Safety Knowledge	**0.593**			
Unsafe Behaviour	**0.743**	**0.623**		
Workplace Environment	**0.668**	**0.582**	**0.712**	

Table 4.18: Confidence Intervals of Heterotrait-Monotrait Ratio (HTMT) of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Safety Knowledge -> Human Error	0.593	0.610	0.351	0.848
Unsafe Behaviour -> Human Error	0.743	0.746	0.520	0.934
Unsafe Behaviour -> Safety Knowledge	0.623	0.631	0.359	0.871
Workplace Environment -> Human Error	0.668	0.670	0.480	0.825
Workplace Environment -> Safety Knowledge	0.582	0.581	0.334	0.802
Workplace Environment -> Unsafe Behaviour	0.712	0.713	0.500	0.877

Table 4.19: Confidence Intervals Bias Corrected of Heterotrait-Monotrait Ratio (HTMT) of PLS Algorithm

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Safety Knowledge-> Human Error	0.593	0.610	0.017	0.277	0.797
Unsafe Behaviour -> Human Error	0.743	0.746	0.003	0.467	0.911
Unsafe Behaviour -> Safety Knowledge	0.623	0.631	0.008	0.325	0.840
Workplace Environment -> Human Error	0.668	0.670	0.002	0.474	0.819
Workplace Environment -> Safety Knowledge	0.582	0.581	-0.001	0.326	0.799
Workplace Environment -> Unsafe Behaviour	0.712	0.713	0.001	0.484	0.867

4.6 Assessment of the Structural Model for Collinearity Issues

4.6.1 Outer and Inner VIF Values

The maximum acceptable value of VIF is 4. Hence, from Table 4.20, the outer VIF values ranging from 1.533 to 3.948 and Table 4.21, the values ranges from 1.454 to 1.885 for the inner VIF values are acceptable (Rogerson, P.A., 2001).

Table 4.20: Outer VIF Values of Collinearity Statistics (VIF) for PLS Algorithm

	VIF
HE1	3.251
HE2	3.838
HE3	**2.343**
HE4	**2.259**
HE5	**2.413**
SK4	**1.533**
SK5	**1.533**
UB1	3.948
UB2	**2.540**
UB3	**1.911**
UB4	3.485
UB5	**2.289**
WE1	**2.577**
WE2	**2.360**
WE3	**2.154**
WE4	**2.382**
WE5	**2.037**

Table 4.21: Inner VIF Values of Collinearity Statistics (VIF) for PLS Algorithm

	Human Error_	**Safety Knowledge_**	**Unsafe Behaviour**	**Workplace Environment**
Human Error				
Safety Knowledge	**1.454**			
Unsafe Behaviour	**1.885**			
Workplace Environment	**1.812**			

4.7 Assessment of the Path-Coefficient

From Table 4.22, the values of the loadings for HE to SK, UB and WK are found in the matrix with values of 0.152, 0.437 and 0.252 respectively for the path coefficients of PLS Algorithm. The value of the T Statistics in Table 4.23 are the values of loadings from HE to SK, UB and WK in Bootstrapping. All T values that are above 1.96 are significant and the P Values are valid for values of less than 0.05 hence, the T and P Values of UB to HE of 3.200 and 0.001 and WE to HE of 2.241 and 0.025 shows that the results of the path coefficient are significant.

However, the T and P values for SK to HE is 1.788 and 0.074 which is a bit less than 1.96 and a bit more than 0.05, hence, this shows that the results are approaching the borderline of significance. A reason for the higher P values may be due to there being too much variability of the data sampled where there may be a random error in the sampling (Frost, J., 2019). From Table 4.24, all of the 2.5% of the cases lie above the upper confidence limit with values of 0.017, 0.133 and 0.023, hence, the confidence limits are 97.5%. Since in Table 4.25 there is no 0 in the 97.5% confidence limits with values of 0.313, 0.676 and 0.453, the path coefficient is significant (Garson, G.D., 2016).

Table 4.22: Matrix of Path Coefficients of PLS Algorithm

	Human Error	**Safety Knowledge**	**Unsafe Behaviour**	**Workplace Environment**
Human Error				
Safety Knowledge	0.152			
Unsafe Behaviour	0.437			
Workplace Environment	0.252			

Table 4.23: Mean, STDEV, T-Values, P-Values of Path Coefficients of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Safety Knowledge→ Human Error	0.152	0.169	0.085	1.788	0.074
Unsafe Behaviour→ Human Error	0.440	0.426	0.137	3.200	0.001
Workplace Environment→ Human Error	0.250	0.249	0.111	2.241	0.025

Table 4.24: Confidence Intervals of Path Coefficients of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Safety Knowledge ->Human Error	0.152	0.180	0.017	0.349
Unsafe Behaviour -> Human Error	0.440	0.426	0.133	0.663
Workplace Environment ->Human Error	0.250	0.249	0.023	0.458

Table 4.25: Confidence Intervals Bias Corrected of Path Coefficients of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Safety Knowledge ->Human Error	0.152	0.180	0.028	-0.012	0.313
Unsafe Behaviour -> Human Error	0.440	0.426	-0.013	0.139	0.676
Workplace Environment ->Human Error	0.250	0.249	0.000	0.019	0.453

4.8 Assessment of the level of R^2 or Adj R^2

Based on the value for R square in Table 4.26 of 0.527, it can be concluded that 52.7% of the data fits the regression model where the higher the value of R square, the better the fit for the model. The decreasing value of R square adjusted compared to R square shows that the predictor did not improve the model more than would be expected (Bhalla, D., 2014).

Table 4.26: Matrix of the level of R^2 and Adj R^2 of PLS Algorithm

	R square	**R Square Adjusted**
Human Error	0.527	0.514

4.8.1 Level of R^2

The T Value in Table 4.27 is 4.207 which is above 1.96 and the P Value is 0.000 which is less than 0.05, hence, the level of R^2 is significant. From Table 4.28, 2.5% of the cases lie above the upper confidence limit with a value of 0.329, hence, the confidence limit is 97.5%. Since in Table 4.29 there is no 0 in the confidence limits, with a value of 0.732, the level of R^2 is significant.

Table 4.27: Mean, STDEV, T-Values and P-Values of the level of R^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Human Error	0.527	0.560	0.125	4.207	0.000

Table 4.28: Confidence Intervals of the level of R^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Human Error	0.527	0.560	0.329	0.786

Table 4.29: Confidence Intervals Bias Corrected of the level of R^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Human Error	0.527	0.560	0.033	0.267	0.732

4.8.2 Adj R^2

Since the value of T Statistics in Table 4.30 for Ajd R^2 is 4.001 and is larger than 1.96 as well as the P Value is 0.000 which is less than 0.05, the level of Adj R^2 is significant. Since in Table 4.31, 2.5% of the cases with value of 0.211 is above the upper limit, the confidence interval is 97.5%. There is no 0 value in Table 4.32 in the confidence interval with a value of 0.725, hence, the Adj R^2 is considered to be significant.

Table 4.30: Mean, STDEV, T-Values and P-Values of the level of Adj R^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Human Error	0.514	0.548	0.12	4.001	0.000

Table 4.31: Confidence Intervals of the level of Adj R^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Human Error	0.514	0.548	0.311	0.780

Table 4.32: Confidence Intervals Bias Corrected of the level of Adj R^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Human Error	0.514	0.548	0.034	0.248	0.725

4.9 Assessment of the Effect Size (f^2)

According to Cohen, 1988, effect size f^2 of 0.02 is small, 0.15 is medium and 0.35 is large. Hence, from Table 4.33 the effects of SK and WK on HE is small whereas the effects of UB on HE is medium. From Table 4.34, T Values for f^2 is 0.702, 0.832 and 0.768 which is smaller than 1.96 whereas the P Values are 0.483, 0.403 and 0.443 which is larger than 0.05. This shows that the level of f^2 is less significant. Since 2.5% of the cases in Table 4.35 are above the upper limit with values of 0.001, 0.014 and 0.002, the confidence interval is 97.5%. None of the values in Table 4.36 in the confidence interval are 0, with values of 0.047, 0.290 and 0.103, hence, f^2 is significant.

Table 4.33: Matrix of f^2 for PLS Algorithm

	Human Error	**Safety Knowledge**	**Unsafe Behaviour**	**Workplace Environment**
Human Error				
Safety Knowledge	0.034			
Unsafe Behaviour	0.214			
Workplace Environment	0.074			

Table 4.34: Mean, STDEV, T-Values and P-Values of the level of f^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Safety Knowledge→ Human Error	0.034	0.060	0.048	0.702	0.483
Unsafe Behaviour→ Human Error	0.217	0.286	0.260	0.832	0.406
Workplace Environment→ Human Error	0.073	0.105	0.095	0.768	0.443

Table 4.35: Confidence Intervals of the level of f^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
Safety Knowledge→ Human Error	0.034	0.060	0.001	0.178
Unsafe Behaviour→ Human Error	0.217	0.286	0.014	0.936
Workplace Environment→ Human Error	0.073	0.105	0.002	0.398

Table 4.36: Confidence Intervals Bias Corrected of the level of f^2 of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Safety Knowledge→ Human Error	0.034	0.180	0.146	-0.066	0.047
Unsafe Behaviour→ Human Error	0.217	0.426	0.210	-0.029	0.290
Workplace Environment→ Human Error	0.073	0.249	0.177	-0.079	0.103

4.10 Assessment of Predictive Relevance: Q^2, q^2 effect size and PLSPredict

4.10.1 Q^2

Based on the values of Q^2 obtained from Table 4.37, Table 4.38, Table 4.39 and Table 4.40, since the values are above 0, this shows that the model has predictive relevance and the values are reconstructed well (ResearchwithFawad, 2021).

Table 4.37: Construct Crossvalidated Redundancy of Blindfolding

	SSO	**SSE**	**Q^2 (=1-SSE/SSO)**
Human Error	585.000	362.368	0.381
Safety Knowledge	234.000	234.000	
Unsafe Behaviour	585.000	585.000	
Workplace Environment	585.000	585.000	

Table 4.38: Construct Crossvalidated Communality of Blindfolding

	SSO	SSE	Q^2 (=1-SSE/SSO)
Human Error	585.000	362.368	0.381
Safety Knowledge	234.000	234.000	
Unsafe Behaviour	585.000	585.000	
Workplace Environment	585.000	585.000	

Table 4.39: Indicator Crossvalidated Redundancy of Blindfolding

	SSO	SSE	Q^2 (=1-SSE/SSO)
HE1	117.000	66.125	0.435
HE2	117.000	64.720	0.447
HE3	117.000	69.404	0.407
HE4	117.000	79.240	0.323
HE5	117.000	82.879	0.292
SK4	117.000	117.000	
SK5	117.000	117.000	
UB1	117.000	117.000	
UB2	117.000	117.000	
UB3	117.000	117.000	
UB4	117.000	117.000	
UB5	117.000	117.000	
WE1	117.000	117.000	
WE2	117.000	117.000	
WE3	117.000	117.000	
WE4	117.000	117.000	
WE5	117.000	117.000	

Table 4.40: Indicator Crossvalidated Communality of Blindfolding

	SSO	SSE	Q^2 (=1-SSE/SSO)
HE1	18.285	5.772	0.684
HE2	22.093	19.256	0.128
HE3	12.513	6.622	0.471
HE4	15.298	9.417	0.384
HE5	18.416	11.880	0.355
SK4	16.414	16.414	
SK5	19.891	19.891	
UB1	16.093	16.093	
UB2	30.642	30.642	
UB3	17.681	17.681	
UB4	17.365	17.365	
UB5	9.171	9.171	
WE1	17.056	17.056	
WE2	27.396	27.396	
WE3	12.696	12.696	
WE4	14.090	14.090	
WE5	9.121	9.121	

4.10.2 PLSPredict

Q^2 can be obtained through two types of techniques namely cross validated redundancy and communality. Based on the values of Q^2 predict from Table 4.41 and Table 4.42, since the values are above 0, it can be concluded that the model has predictive relevance and is reconstructed well (ResearchwithFawad, 2021).

Table 4.41: MV Prediction Summary of PLSPredict

	RMSE	**MAE**	**MAPE**	**Q^2_predict**
HE5	1.027	0.777	44.118	0.244
HE2	0.869	0.603	35.524	0.397
HE3	0.856	0.618	37.424	0.368
HE1	0.875	0.631	37.575	0.393
HE4	0.933	0.697	36.516	0.284

Table 4.42: LV Prediction Summary of PLSPredict

	RMSE	**MAE**	**MAPE**	**Q^2_predict**
HE5	1.060	0.802	44.613	0.194
HE2	0.958	0.666	38.393	0.267
HE3	0.927	0.645	38.775	0.258
HE1	0.954	0.653	38.777	0.279
HE4	0.990	0.749	38.881	0.193

4.11 Assessment of the GoF

4.11.1 Model Fit

The value of SRMR should be between 0 to 0.08 where the value from Table 4.43 obtained is 0.069 whereas the value of 0.810 which is close to 0.90 for NFI indicates a good model fit. Other than that, the value of rms Theta obtained from Table 4.44 is above 0.12 (Henseler et al., 2014) which is 0.190. However, the values are close together which indicated a partially good model fit.

Table 4.43: Model Fit of the Fit Summary of PLS Algorithm

	Saturated Model	**Estimated Model**
SRMR	0.069	0.069
d_ULS	0.729	0.729
d_G	0.433	0.433
Chi-Square	286.089	286.089
NFI	0.810	0.810

Table 4.44: Model Fit of rms Theta of PLS Algorithm

rms Theta	0.190

4.11.2 SRMR

The value of the SRMR from Table 4.45 is less than 0.08 and is considered to be a good fit.

Table 4.45: Confidence Intervals of the SRMR of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**95%**	**99%**
Saturated Model	**0.069**	0.049	0.061	0.066
Estimated Model	**0.069**	0.050	0.061	0.066

4.11.3 d_ULS and d_G

For d_ULS and d_G, the upper boundary of the 95% and 99% confidence intervals should be larger than the value of the original sample in order to indicate that the model has a good fit. The value for the original sample for d_ULS in Table 4.46 is larger than the value of the confidence interval and the difference between the confidence interval and the original sample for d_ULS are slightly more than 0.05, hence. The model fit is slightly established.

Whereas for d_G from Table 4.47, the value of the original sample is less than the values of the confidence intervals and the difference between the original sample and the confidence intervals are less than 0.05, hence the model fit is established (Ringle, 2015).

Table 4.46: Confidence Intervals of d_ULS of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**95%**	**99%**
Saturated Model	**0.728**	0.378	0.575	0.673
Estimated Model	**0.728**	0.381	0.569	0.661

Table 4.47: Confidence Intervals of d_G of Bootstrapping

	Original Sample (O)	**Sample Mean (M)**	**95%**	**99%**
Saturated Model	**0.433**	0.336	0.445	0.494
Estimated Model	**0.433**	0.337	0.454	0.533

4.12 Summary

The structural model shows the significance of the relationship between the independent variables and the dependent variable. Based on the values of the loadings between the independent and dependent variables,

H1: There is a significant relationship between safety knowledge to human error.

H2: There is a significant relationship between unsafe behaviour to human error.

H3: There is a significant relationship between workplace environment to human error.

Based on the results obtained, unsafe behaviour has the strongest effect on human error among all the variables in the study with a factor loading of 0.437. workplace environment has the second strongest effect on human error with a factor loading of 0.252. Lastly, safety knowledge has the weakest effect on human error with a factor loading of 0.152.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

H1: There is a significant impact of safety knowledge on human error.

The hypothesis that was proposed is accepted where based on the results obtained, there is a significant positive relationship between safety knowledge and human error. Safety knowledge is the ability of knowing the ways of performing work safely (Nykänen et al., 2020). When workers have safety knowledge they are less likely to perform their work carelessly and are more likely to seek the help of their colleagues or superiors when facing any issues. They will also have the experience which enables them to be sure of safety issues when performing their duties. Safety knowledge can be enhanced by providing workers with safety training which prepares workers with the skills needed to recognise and manage workplace hazards (Mohammadfam, I. et al., 2021).

H2: There is a significant impact of unsafe behaviour on human error.

The hypothesis that was proposed is accepted where based on the results obtained, there is a significant positive relationship between unsafe behaviour and human error. The understanding and study of unsafe behaviour can help ensure that workers and managers alike can be prepared with the appropriate and adequate tools in order to reduce unsafe behaviour and reduce the occurrences of on-site accidents (DongpingA, et al. 2016). The behaviour of workers in the workplace are important in order to maintain safety and order where it is important to comply with the safety guidelines and rules in the workplace. The workers will also use Personal Protective Equipment (PPE) when necessary and only perform work that is part of their main job without performing other work that may not have been taught to them which may put others or themselves at risk due to unfamiliarity. Other than that, the workers will also perform their work accurately and safety based on the rules and regulations without taking high risks (Shakerian et.al., 2019).

H3: There is a significant impact of workplace environment on human error.

The hypothesis that was proposed is accepted where based on the results obtained, there is a significant positive relationship between workplace environment and human error. The basic qualities of a reasonable work environment are such as normal surrounding temperature, odourless, uncongested, dustless and peaceful conditions (McGarth, 1978). In a good working environment, there will be all the necessary tools and equipment in order to carry out the workers specified jobs as well as adequate team support in order for them to be able to ask for any guidance or help when necessary, from their fellow teammates or colleagues (Moura R. et al., 2015). The regular work hours also enable the workers to be well rested and further be able to focus on their jobs as they will have alert minds. The workers will also be able to carry out their tasks properly and well if there is an adequate amount of time given to complete their tasks. Lastly, the layout of the workplace is also important in order to navigate the workplace properly and also to avoid injuries from any sharp corners or blind spots as well as to be able to locate equipment or machinery in the workplace easily (Anoosheh, M. et al., 2008).

Lastly, the relationship between safety knowledge, unsafe behaviour and workplace environment to human error are significant. This shows that the objective to find out the causes of human error in the manufacturing industry has been fulfilled. The benefit of this research is that it will help to reduce the occurrences of human error in not only the manufacturing industry but can also be used for other various industries. Finally, this study can also help to spread awareness about the causes of human error in order to prevent injuries or harm to the workers.

5.2 Recommendations for future work

One of the recommendations for future work is the number of respondents should be increased in order to obtain more accurate results where the reliability and validity of the model can be increased with the increase in the number of respondents. Other than that, since the study is based in Malaysia, future researchers should perform the analysis in other countries as well since there are various manufacturing industries all over the world which will also help to increase the accuracy of the results. The survey is also mostly focused in states such as Penang and Selangor as well as in the Electrical and Electronics industry, hence, it will be beneficial to encompass and focus on other states and other industries as well in order to reduce sampling bias.

REFERENCES

Aksorn, T., and Hadikusumo, B. H. W., 2008. Critical success factors influencing safety program performance in Thai construction projects. *Safety Science*, [e-journal] 46(4), pp.709–727. https://doi.org/10.1016/j.ssci.2007.06.006.

Anoosheh, M., Ahmadi, M., Faghihzadeh, S. and Vaismoradi, M., 2008. Causes and management of nursing practice errors: a questionnaire survey of hospital nurses in Iran, *International Nursing Review*, [e-journal] 55(3) pp. 288-295. https://doi.org/10.1111/j.1466-7657.2008.00623.x.

Antonsen, S., 2009. Safety culture assessment: A Mission Impossible?. *Journal of Contingencies and Crisis Management*, [e-journal] 17(4) pp. 242-254. https://doi.org/10.1111/j.1468-5973.2009.00585.x.

Ayob, A., Shaari, A. A., Zaki, M. F. M., Munaaim, M. A. C., 2017. Fatal occupational injuries in the Malaysian construction sector– causes and accidental agents. *Earth and Environmental Science*, [e-journal] 140. https://doi.org/doi :10.1088/1755-1315/140/1/012095.

Bentler, P. M., & Chou, C. P., 1987. Practical issues in structural modeling. *Sociologial Methods and Research*, 16(1), pp.78-117.

Bevans, 2020. Multiple Linear Regression, A Quick and Simple Guide. Available through: Scribbr website: <https://www.scribbr.com/statistics/multiple-linear-regression/> [Accessed 2 April 2022].

Bhalla, D., 2017. *Difference between Adjusted R-squared and R-square*. Available through: Listen Data website: <https://www.listendata.com/2014/08/adjusted-r-squared.html> [Accessed 2 April 2022].

Cacciabue, P.C., 2000. Human factors impact on risk analysis of complex systems. *Journal of Hazardous Materials*, [e-journal] 71, pp.101-116. https://doi.org/10.1016/S0304-3894(99)00074-6.

Cates, C.J., Elizabeth, S. and Welsh, E.J., 2014. How to make sense of a Cochrane systematic review. *Breathe*, [e-journal] 10, pp. 134-144. https://doi.org/10.1183/20734735.003514.

Chin, W. W., Marcolin, B. L., and Newsted, P. R., 2003. A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects: Results from a Monte Carlo Simulation Study and an Electronic Mail Emotion/Adoption Study. *Information Systems Research*, [e-journal] 14(2), pp. 189-217. https://doi.org/10.1287/isre.14.2.189.16018.

Chi, S., Han, S., Kim, D. and Shin, Y., 2015. Accident risk identification and its impact analyses for strategic construction safety management. *Journal of Civil Engineering Management*, [e-journal] 21(4), pp. 524-538. https://doi.org/10.3846/13923730.2014.890662.

Choudhry, R. M., and Fang, D., 2008. Why operatives engage in unsafe work behaviour: Investigating factors on construction sites. *Safety Science*, [e-journal] 46(4), pp. 566–584. https://doi.org/ 10.1016/j.ssci.2007.06.027.

Chyung, S., Roberts, K., Sawanson, I. and Hankinson, A., 2017. Evidence-Based Survey Design: The Use of a Midpoint on the Likert Scale. *Performance Improvement*, [e-journal] 56(10), pp. 15-23. https://doi.org/10.1002/pfi.21727.

Clark, L. A., & Watson, D., 1995. Constructing validity: basic issues in objective scale development. *Psychological Assessment,* [e-book] *7*(3), 309–319. https://doi.org/10.1037/1040-3590.7.3.309

Cohen, J., 1988. *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Cortina, J.M., 1993. What Is Coefficient Alpha? An Examination of Theory and Applications. *Journal of Applied Psychology*, [e-journal] 78(1), pp. 98-104. Available at: <https://www.psycholosphere.com/what%20is%20coefficient%20alpha%20by%20Cortina.pdf> [Accessed 21 March 2022].

Decamp, W. and Herskovitz, K., 2015. The Theories of Accident Causation. *Security Supervision and Management*, [e-journal] pp. 71-78. https://doi.org/10.1016/B978-0-12-800113-4.00005-5.

Department of Statistics Malaysia Official Portal, 2021. Big Data Analytics: National Occupational Accident Statistics 2020'. Available through: Department of Statistics Malaysia Official Portal website: <https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=492&bul_id=czB6elhvaWtoVmgwVktXUGJqRElLZz09&menu_id=WjJGK0Z5bTk1ZElVT09yUW1tRG41Zz09> [Accessed 15 August 2021].

Erdfelder, E., Franz, F. and Axel, B., 1996. GPOWER: A general power analysis program. *Behavior Research Methods, Instruments, & Computers*, [e-journal] 28(1) pp. 1-11. https://doi.org/10.3758/BF03203630.

Fang, D., Zhao, C. and Mengchun, Z.,2016. A Cognitive Model of Construction Workers' Unsafe Behaviours. *Journal of Construction Engineering and Management,* [e-journal] 142(9). https://doi.org/ 10.1061/(ASCE)CO.1943-7862.0001118.

Farmers, E. and Chambers, E.G., 1939. A study of accident proneness among motor drivers. *Journal of the Royal Statistical Society,* [e-journal] 103(2), pp. 254-256. https://doi.org/10.2307/2980423.

Federation of Malaysian Manufacturers, 2021. About FMM. Available through: Federation of Malaysian Manufacturers website: <https://www.fmm.org.my/About_FMM-@-About_FMM.aspx> [Accessed 12 August 2021].

Feyer, A.M., Williamson, A.M., Cairna and David, R., 1997.The involvement of human behaviour in occupational accidents: errors in contest. *Safety Science*, [e-journal] 25(1-3), pp. 55-65. https://doi.org/10.1016/S0925-7535(97)00008-8.

Frost, J., 2019. *Can High P-Values Be Meaningful*. Available through: Statistics by Jim website: <https://statisticsbyjim.com/hypothesis-testing/high-p-values/> [Accessed 2 April 2022].

Garrett, J., and Teizer, J., 2009. Human factors analysis classification system relating to human error awareness taxonomy in construction safety. *Journal of Construction Engineering Management,* [e-journal] 135 (8): 754–763. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000034.

Garson, G.D., 2016. Partial Least Squares: Regression and Structural Equation Models. *Statistical Associates Publishers, Asheboro*. [e-book] Available at: <http://www.statisticalassociates.com/pls-sem_p.pdf> [Accessed 3 April 2022].

Greenwood, M. and Woods, H. M., 1919. The incidence of industrial accidents upon individuals with special reference to multiple accidents. *Industrial Fatigue Research Board, Medical Research Committee* [e-journal]. Available at: <https://archive.org/details/incidenceofindus00grea> [Accessed 3 August 2021].

Griffin, M. A. and Curcuruto, M., 2016. Safety climate in organisations. *The Annual Review of Psychology and Organisational Behaviour*, [e-journal] 3(4) pp. 191-212. https://doi.org/10.1146/annurev-orgpsych-041015-062414.

Griffin, M. A. and Neal, A., 2000. Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge and motivation. *Journal of Occupational Health Psychology*, [e-journal] 5(3), pp. 347. https://doi.org10.1037//1076-8998.5.3.347.

Haatainen, J., 2010. Workplace Accidents in Finnish Manufacturing Maintenance. *IEEE International Conference on Industrial Engineering and Engineering Management*, [e-journal] pp. 1514-1518. https://doi.org/10.1109/IEEM.2010.5674156.

Haenlein, M. and Kaplan, A. M., 2004. A beginner’s guide to partial least squares analysis. *Understanding Statistics*, [e-journal] 3(4), 283–297. https://doi.org/10.1207/s15328031us0304_4.

Hale, A.R. and Glendon, A.I.,1987. A Review of: Individual Behaviour in the Control of Danger. *Ergonomics*, [e-journal] 32(3), pp. 345-346. https://doi.org/10.1080/00140138908966095.

Hair, J. F. Jr., Anderson, R. E., Tatham, R. L., Black, W. C., 1996. Multivariate Data Analysis, 3rd ed. New York: Macmillan.

Hair, J., Hult, G. T. M., Ringle, C., Sarstedt, M., 2014. Principles of Structural Equation Modelling. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM).* [e-book] https://doi.org/10.1007/978-3-030-80519-7.

Hassan. Z., Schattner, P. and Mazza, D., 2006. Doing A Pilot Study: Why Is It Essential?. *Malays Fam Physician,* [e-journal] 1(2), pp. 70-73. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4453116/> [Accessed 28 July 2021].

Haste, N., 2005. Accidents and Agenda: An examination of the processes that follow from accidents or incidents of high potential in several industries and their effectiveness in preventing further accidents. *The Royal Academy of Engineering*. [e-book] Available at: <http://www.raeng.org. uk/news/publications/> [Accessed 1 Auguat 2021].

Heinrich, H. W., Petersen, D., and Roos, N. , 1950. *Industrial Accident Prevention: A Scientific Approach*. 3rd ed.

Heinrich, H. W., Petersen, D., and Roos, N., 1980. *Industrial Accident Prevention: A safety management approach*. 4th edn.

Henseler, J., Ringle, C.M. and Sarstedt, M., 2015. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science,* [e-journal] 43(1), pp. 115-135. https://doi.org/10.1007/s11747-014-0403-8.

Hosseinian, S. S. and Torghabeh, Z. J., 2012. Major Theories of Construction Accident Causation Models: A Literature Review. *International Journal of Advances in Engineering and Technology,* [e-journal] 4(2) pp. 53-66. Available at: <https://www.researchgate.net/publication/268439084_Major_theories_of_construction_accident_causation_model> [Accessed 20 August 2021].

Hwang, H., Malhotra, N. K., Kim, Y., Tomiuk, M. A., and Hong, S., 2010. A comparative study on parameter recovery of three approaches to structural equation modelling. *Journal of Marketing Research,* [e-journal] 47, pp. 699-712. https://doi.org/10.2307/20751534.

Kines, P. and Pedersen L.M., 2011. Why do workers work safely? Development of safety motivation questionnaire scales. *Safety Science Monitor*, [e-journal] 1(10). Available at: <https://www.researchgate.net/publication/263702590> [Accessed 12 August 2021].

Kline, R. B., 2011. *Principles and practice of structural equation modeling*. New York: Guilford Press.

Kock, N. & Hadaya, P., 2018. Minimum sample size estimation in PLS-SEM: The inverse square root and gamma-exponential methods. *Information Systems Journal,* [e-journal] 28(1), 227–261. https://doi.org/10.1111/isj.12131

Kumar, R. M. L., Park, S., and Subramaniam, C., 2008. Understanding the Value of Countermeasure Portfolios in Information Systems Security. *Journal of Management Information Systems*, [e-journal] 25(2), pp. 241-280. https://doi.org/10.2753/MIS0742-1222250210.

Likert, R., 1932. A technique for the measurement of attitudes. *Archives of Psychology*, [e-journal] 22(140), pp. 5-55. Available at: <https://www.researchgate.net/publication/262011454_Likert> [Accessed 12 July 2021].

Mahapoonyanont, N., Mahapoonyanont, T., Pengkaew, N. and Rojarek, K., 2010. Power of the test of One-Way Anova after transforming with large sample size data. *Procedia: Social and Behavioral Sciences*, [e-journal] 9, pp. 933-937. https://doi.org/10.1016/j.sbspro.2010.12.262.

Mangano, J., 2004.Three Mile Island: Health Study Meltdown. *Bulletin of the Atomic Scientists*.[e-journal] https://doi.org/10.2968/060005010.

Martínez-Córcoles, M., Gracia, F.J., Tomás, Peiró, J.M. and Schöbel, M., 2011. Empowering team leadership and safety performance in nuclear power plants: A multilevel approach. *Safety Science*, [e-journal] 51 pp. 293-301. https://doi.org/10.1016/j.ssci.2012.08.001.

McGrath J.E., 1978. Stress and Behavior in Organizations. *Handbook of Industrial and Organizational Psychology*, pp: 1351-1395.

Memon, M.A., Ting, H., Cheah, J. H., Ramayah, T., Chuah, F., Cham, T. H., 2020. Sample Size for Survey Research: Review and Recommendations. *Journal of Applied Structural Equation Modelling*, [e-journal] 4(2). https://doi.org/10.47263/JASEM.4(2)01.

Mohammadfam, I., Mahdinia, M., Soltanzadeh, A. and Aliabadi, M., 2021. A path analysis model of individual variables predicting safety behavior and human error: The mediating effect of situation awareness. *International Journal of Industrial Ergonomics*, [e-journal] 84. https://doi.org/10.1016/j.ergon.2021.103144.

Moura, R., Beer, E. Patelli, E. and Lewis, J., 2015. Human error analysis: Review of past accidents and implications for improving robustness of system design', *Safety and Reliability: Methodology and Applications*, [e-journal] pp. 1073-1082. https://doi.org/10.1201/b17399-147.

Ng, P.K., Jee, K.S., Saptari, A., and Leau, J. X., 2014.The Effects of Office Equipment Familiarity in Reducing Human Errors and Accidents. *Journal of Applied Mechanics and Materials*, [e-journal] 564, pp. 717-722. https://doi.org/10.4028/www.scientific.net/AMM.564.717.

Nordlöf, H., Wiitavaara, B., Högberg, H. and Westerling, R., 2015. A cross-sectional study of factors influencing occupational health and safety management practices in companies. *Safety Science,* [e-journal] 95, pp. 92-103. https://doi.org/10.1016/j.ssci.2017.02.008.

Nykänen, M., Puro, V., Tiikkaja, M., Kannisto, H., Lantto, E., Simpura, F., 2020. Implementing and evaluating novel safety training methods for construction sector workers: results of a randomized controlled trial. *Journal of Safety Research*, [e-journal] 75, pp. 205-221. https://doi.org/10.1016/j.ssci.2019.04.037.

Ostertagova, E. and Ostertag, O., 2013. Methodology and Application of One-way ANOVA. *American Journal of Mechanical Engineering*, [e-journal] 1(7), pp. 256-261. https://doi.org/10.12691/ajme-1-7-21.

Petrillo, A., Felice, F. D., Longo, F., Bruzzone, A., 2017. Factors affecting the human error: representations of mental models for emergency management. *International Journal of Simulation and Process Modelling*, 12(3) pp.287 – 299, https://doi.org/10.1504/IJSPM.2017.10006511.

Reason, J.T., 1990. Human Error. Cambridge University Press. [e-book]. Available at: <https://books.google.com.my/books?hl=en&lr=&id=WJL8NZc8lZ8C&oi=fnd&pg=PR9&dq=Reason,+J.T.+(1990)+Human+Error.+Cambridge+University+Press&ots=AnPf7h7p4c&sig=pJHOGb0Bg1cGNzRkw5ERP9SDrOc#v=onepage&q=Reason%2C%20J.T.%20(1990)%20Human%20Error.%20Cambridge%20University%20Press&f=false> [Accessed 20 July 2021].

Reason, J. T., 2008. *The Human Contribution: Unsafe Acts, Accidents and Heroic Recoveries.* 1st edn.

Reinartz, W.J., Haenlein, M and Henseler, J., 2009. An empirical comparison of the efficacy of covariance-based and variance-based SEM. *International Journal of Market Research*, [e-journal] 26 (4), pp. 332–344. https://doi.org/10.1016/j.ijresmar.2009.08.001.

Research With Fawad, 2021. *Introduction to Data Analysis using SMART-PLS.* Available though: Research With Fawad website: <https://researchwithfawad.com/index.php/lp-courses/basic-and-advance-data-analysis-using-smart-pls/how-to-start-data-analysis-using-smart-pls/> [Accessed 19 April 2022].

Reyes, R.M., Riva, J., Maldonado, A.A., Woocay, A. and Rodolfo, A., 2012. Association between Human Error and Occupational Accidents' Contributing Factors for Hand Injuries in the Automotive Manufacturing Industry. *Procedia Manufacturing*, [e-journal] 3, pp. 6498-6504. https://doi.org/10.1016/j.promfg.2015.07.936.
Ridley, J. and Channing, J., 2012. *Safety at Work*. 7th Edition.

Ringle, Christian M., Wende, Sven, & Becker, Jan-Michael., 2015. *SmartPLS 3*. Available through: SmartPLS website: <https://www.smartpls.com> [Accessed 13 April 2022].

Rogerson, P. A., 2001. Statistical methods for geography. London: Sage.

Runciman, W.B., Sellen, A., Webb, R.K., Williamson, J.A., Currie, M., Morgan, C. and Russell, W.J., 1990. Errors, incidents and accidents in anesthetic practice. *Anesthetic and Intensive Care*, [e-journal] 21, pp. 506–519. https://doi.org/10.1177/0310057X9302100506.

Saedi, A.M., Majid, A. A. and Isa, Z., 2019. Relationships between safety climate and safety participation in the petroleum industry: A structural equation modeling approach. *Safety Science*, [e-journal] 121, pp. 240-248. https://doi.org/10.1016/j.ssci.2019.08.045.

Salminen, S., Tallberg, T., 1996. Human errors in fatal and serious occupational accidents in Finland. *Ergonomics*, [e-journal] 39, pp. 980-988. https://doi.org/10.1080/00140139608964518.

Saurin, T. A., Formoso, C. T., and Cambraia, F. B., 2005. Analysis of a safety planning and control model from the human error perspective. *Engineering, Construction and Architectural Management*, [e-journal] 12(3), 283–298. https://doi.org/10.1108/09699980510600134.

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J., 2006. Reporting structural equation modeling and and confirmatory factor analysis results: A review. *The Journal of Eduacational Research*, [e-journal] 99(6), 323-338. https://doi.org/10.3200/JOER.99.6.323-338.

Selmi, A.A. and Murray, V., 2016. The Chernobyl Disaster and Beyond: Implications of the Sendai Framework for Disaster Risk Reduction 2015–2030. *PLOS Medicine*, [e-journal] 13(4), https://doi.org/10.1371/journal.pmed.1002017.

Serdar, C. C., Cihan, M., Yücel, D., & Serdar, M. A., 2015. Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies. *Biochemia medica*, [e-journal] 31(1), 010502. https://doi.org/10.11613/BM.2021.010502.

Shakerian, M., Choobineh, A., Jahangiri, M., Hasanzedah, J. and Nami, M., 2019. Is "Invisible Gorilla" self-reportedly measurable? Development and validation of a new questionnaire for measuring cognitive unsafe behaviours of front-line industrial workers. *International Journal of Occupational Safety and Ergonomics*, [e-journal] 27(3) pp. 852-866. https://doi.org/10.1080/10803548.2019.1664809 .

Statsoft, 2013. Structural Equation Modeling. Statsoft Electronic Statistics Textbook. [e-book] Available at: <http://www.statsoft.com/textbook/structural-equation-modeling/> [Accessed 21 July 2021].

Teo, E. A. L., Ling, F. Y. Y., & Chong, A. F. W., 2005. Framework for project managers to manage construction safety. *International Journal of Project Management*, [e-journal] 23(4), pp. 329–341. https://doi.org/10.1016/j.ijproman.2004.09.001.

The Commissioner of Law Revision, Malaysia, 2006. Act 514 Occupational Health and Safety Act 1994. Laws of Malaysia. [e-book] Available at: <https://legal.usm.my/v3/phocadownload/laws/Occupational%20Safety%20and%20Health%20Act%20-%20Act%20514.pdf> [Accessed 22 July 2021].

Wenwen, S., Fuchuan, J., Qiang, Z., Jingjing, C., 2011. Analysis and Control of Human Error. *First International Symposium on Mine Safety Science and Engineering*, [e-journal] 26, pp. 2126-2132. https://doi.org/10.1016/j.proeng.2011.11.2415.

Wong, K. K., 2010. Handling small survey sample size and skewed dataset with partial least square path modelling. *The Magazine of the Marketing Research and Intelligence Association*, [e-journal] pp. 20-23. Available at: <https://www.researchgate.net/publication/268449451_Handling_small_survey_sample_size_and_skewed_dataset_with_partial_least_square_path_modelling> [Accessed 21 August 2021].

Wong, K.K., 2013. Partial Least Squares Structural Equation Modeling (PLS-SEM) Techniques Using SmartPLS. *Marketing Bulletin*, [e-journal] pp 1-32. Available at: <https://www.researchgate.net/publication/268449353_Partial_least_square_structural_equation_modeling_PLS-SEM_techniques_using_SmartPLS> [Accessed 12 July 2021].

Yeow, J. A., Tan, K.S., Chin, T.S. and Shiau, C.E., 2012.A review on ergonomics factors that lead to stress in manufacturing industry. *Proceeding of the International Conference of Management, Economics and Finance*. [e-journal] Available at: <https://www.researchgate.net/publication/249649329_A_Review_On_Ergonomic_Factors_that_Lead_to_Stress_in_Manufacturing_Industry> [Accessed 10 July 2021].

Yeow, J.A., Ng, P.K., Tan, K.S., Chin, T.S., and Lim, W. Y., 2014. Effects of Stress, Repetition, Fatigue and Work Environment on Human Error in Manufacturing Industries. *Journal of Applied Sciences*, [e-journal] 14(24), pp. 3464-3471. https://doi.org/10.3923/jas.2014.3464.3471.

Zerguine, H., Tamrin, S., and Jalaludin, J.,2017. D6-3 Evaluation of Safety Behavior and Work-related Injuries among Foreign Construction Workers in Malaysia. *The Japanese journal of ergonomics*, [e-journal] 53, pp. 580-583. https://doi.org/10.5100/jje.53.S580.

Zohar, D., 2000. A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs. *Journal of Applied Psychology*, [e-journal] 85(4), pp. 587. https://doi.org/10.1037/0021-9010.85.4.587.

Zohar, D., 2011. Safety climate: conceptual and measurement issues. *Handbook of Occupational Health Psychology*, [e-journal] pp. 123-142. https://doi.org/10.1037/10474-006.

APPENDICES

Appendix 1: Google Form for the Survey of the Study of the Workplace Accidents Caused by Human Error in the Manufacturing Industry Using Structural Equation Modelling

Study of the Workplace Accidents Caused by Human Error in the Manufacturing Industry Using Structural Equation Modelling (SEM)

Dear respondent,

I am an undergraduate student of Bachelor of Engineering (Hons) Mechanical Engineering at Universiti Tunku Abdul Rahman (UTAR) and I am currently conducting a research on the:

Study of the Workplace Accidents Caused by Human Error in the Manufacturing Industry using Structural Equation Modeling (SEM)

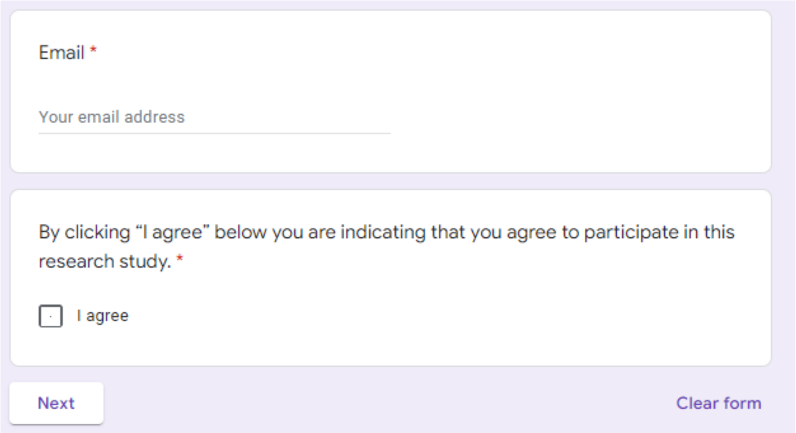
This research study is a compulsory subject to partially fulfil the requirements of the degree program. This questionnaire is carefully designed to be completed in no more than 15 minutes. This questionnaire focuses on industrial manufacturing companies in Malaysia. The attached questionnaire consists of a series of sections which have a demographic profile and are a measurement of dependent and independent variables of our study.

I would appreciate if you would spend some of your time to complete the enclosed questionnaire based on your own knowledge and understanding. Your cooperation is highly appreciated and thank you for spending your precious time to fill in the questionnaire.

Lastly, your responses will be kept strictly PRIVATE AND CONFIDENTIAL as they will and only be used solely for our research purposes.

Supervisor
Name: Mr. Cheong Wen Chiet
Faculty: Lee Kong Chian Faculty of Engineering and Science
Department: Department of Mechanical and Material Engineering
Contact: +603-90860288
Email: cheongwc@utar.edu.my

Student
Name: Natalee Corbett
Faculty: Lee Kong Chian Faculty of Engineering and Science
Department: Department of Mechanical and Material Engineering
Contact: +6012-4416081
Email: nataleec37@utar.edu.my

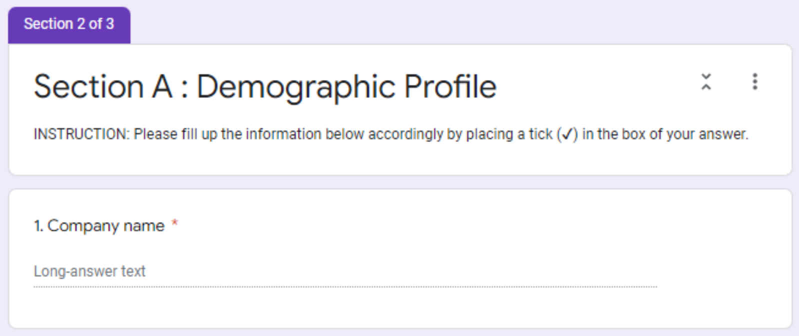


Email *

Your email address

By clicking “I agree” below you are indicating that you agree to participate in this research study. *

☐ I agree

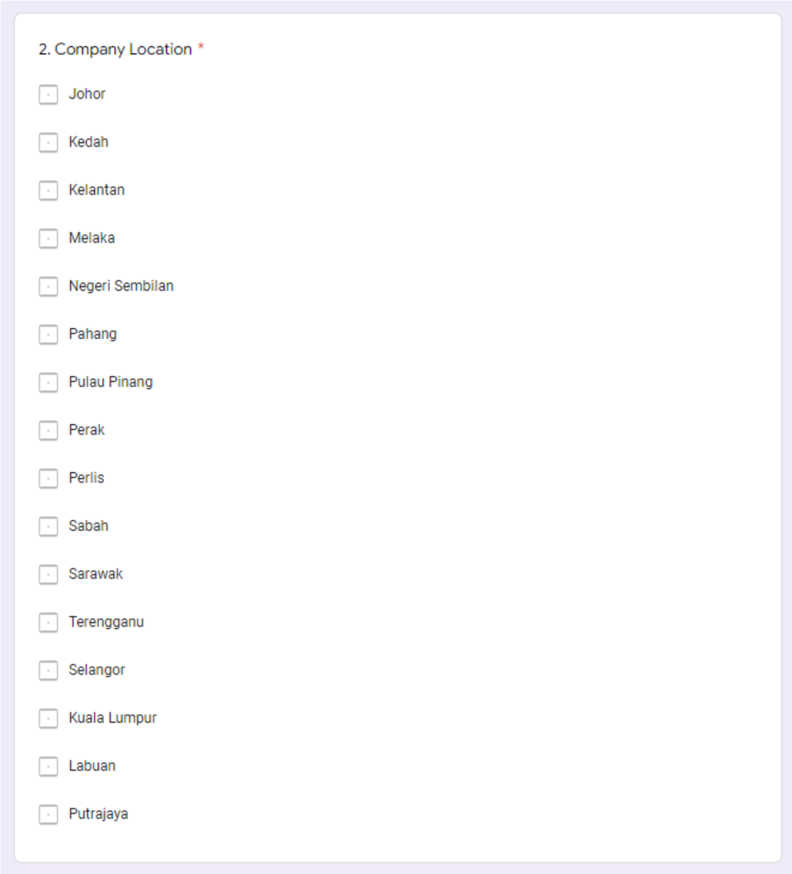


Section A : Demographic Profile

INSTRUCTION: Please fill up the information below accordingly by placing a tick (✓) in the box of your answer.

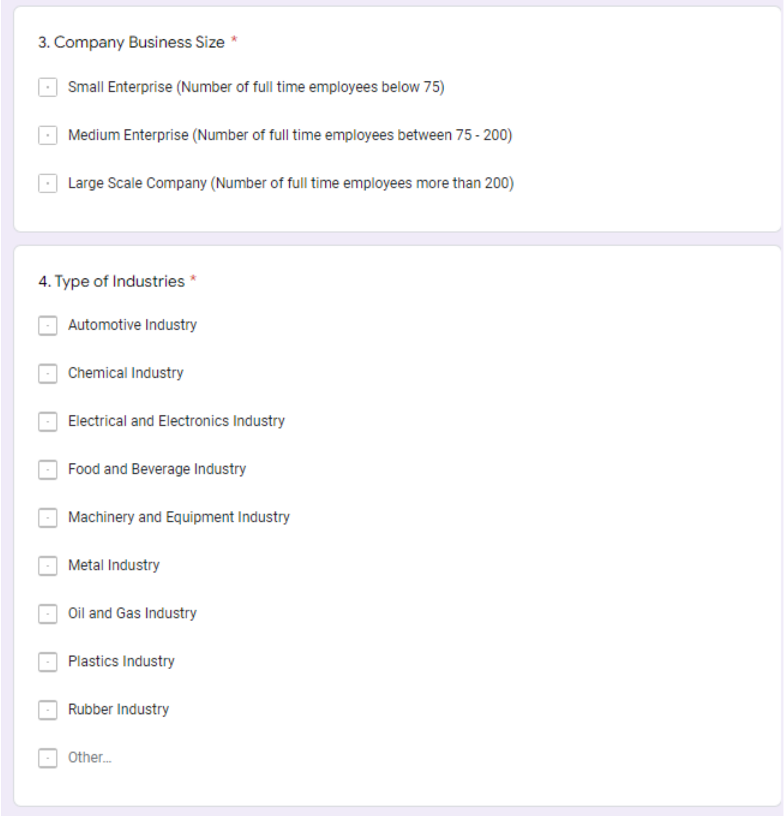
1. Company name *

Long-answer text



2. Company Location *

- ☐ Johor
- ☐ Kedah
- ☐ Kelantan
- ☐ Melaka
- ☐ Negeri Sembilan
- ☐ Pahang
- ☐ Pulau Pinang
- ☐ Perak
- ☐ Perlis
- ☐ Sabah
- ☐ Sarawak
- ☐ Terengganu
- ☐ Selangor
- ☐ Kuala Lumpur
- ☐ Labuan
- ☐ Putrajaya



3. Company Business Size *

☐ Small Enterprise (Number of full time employees below 75)

☐ Medium Enterprise (Number of full time employees between 75 - 200)

☐ Large Scale Company (Number of full time employees more than 200)

4. Type of Industries *

☐ Automotive Industry

☐ Chemical Industry

☐ Electrical and Electronics Industry

☐ Food and Beverage Industry

☐ Machinery and Equipment Industry

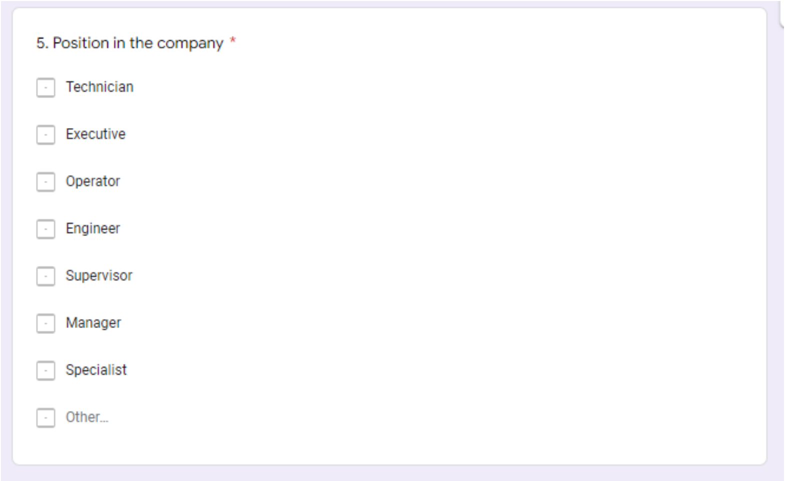
☐ Metal Industry

☐ Oil and Gas Industry

☐ Plastics Industry

☐ Rubber Industry

☐ Other...



5. Position in the company *

☐ Technician

☐ Executive

☐ Operator

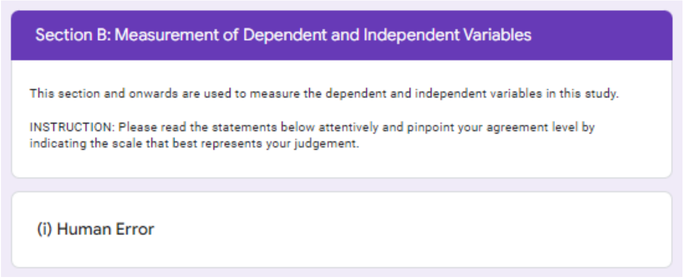
☐ Engineer

☐ Supervisor

☐ Manager

☐ Specialist

☐ Other...

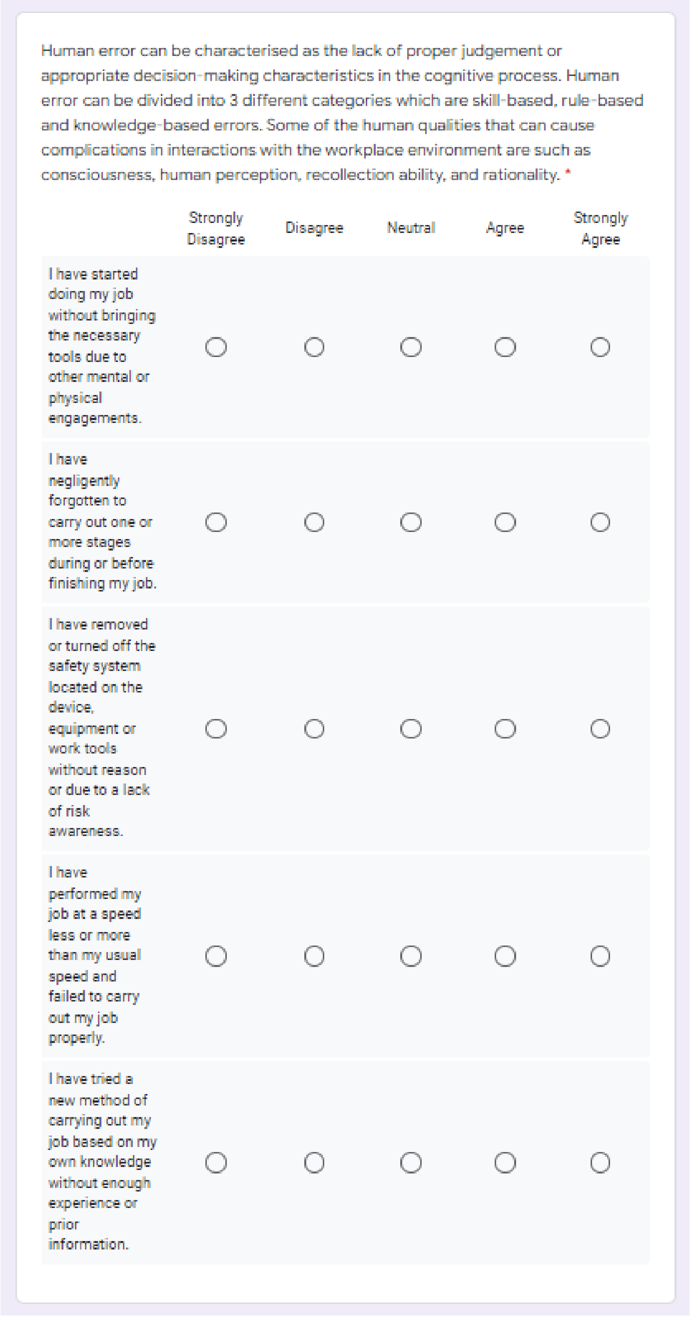


Section B: Measurement of Dependent and Independent Variables

This section and onwards are used to measure the dependent and independent variables in this study.

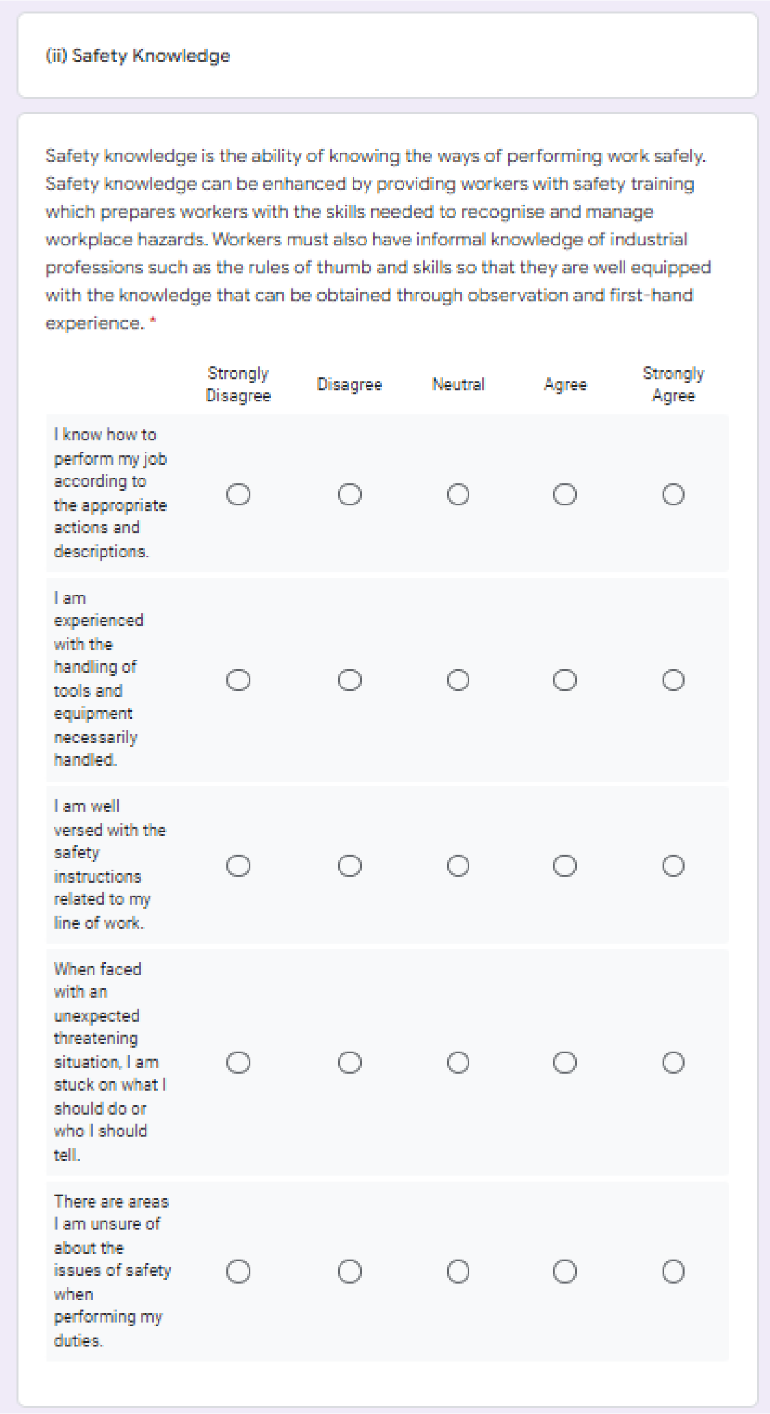
INSTRUCTION: Please read the statements below attentively and pinpoint your agreement level by indicating the scale that best represents your judgement.

(i) Human Error



Human error can be characterised as the lack of proper judgement or appropriate decision-making characteristics in the cognitive process. Human error can be divided into 3 different categories which are skill-based, rule-based and knowledge-based errors. Some of the human qualities that can cause complications in interactions with the workplace environment are such as consciousness, human perception, recollection ability, and rationality. *

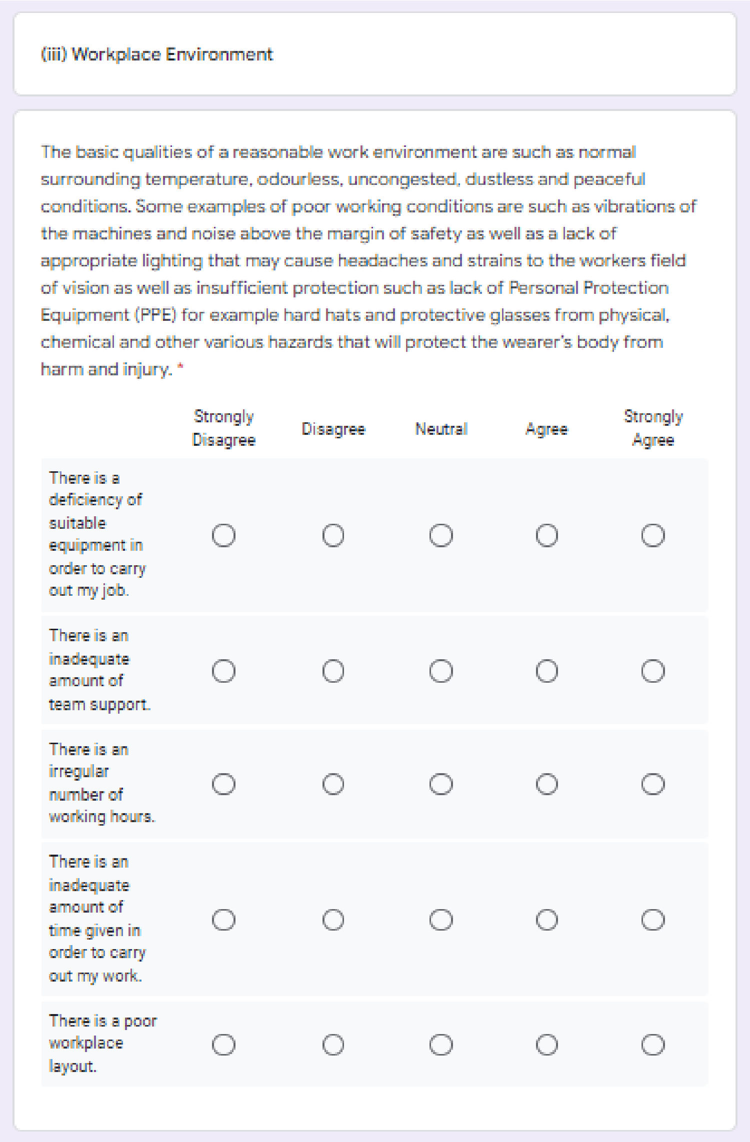
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have started doing my job without bringing the necessary tools due to other mental or physical engagements.	○	○	○	○	○
I have negligently forgotten to carry out one or more stages during or before finishing my job.	○	○	○	○	○
I have removed or turned off the safety system located on the device, equipment or work tools without reason or due to a lack of risk awareness.	○	○	○	○	○
I have performed my job at a speed less or more than my usual speed and failed to carry out my job properly.	○	○	○	○	○
I have tried a new method of carrying out my job based on my own knowledge without enough experience or prior information.	○	○	○	○	○



(ii) Safety Knowledge

Safety knowledge is the ability of knowing the ways of performing work safely. Safety knowledge can be enhanced by providing workers with safety training which prepares workers with the skills needed to recognise and manage workplace hazards. Workers must also have informal knowledge of industrial professions such as the rules of thumb and skills so that they are well equipped with the knowledge that can be obtained through observation and first-hand experience. *

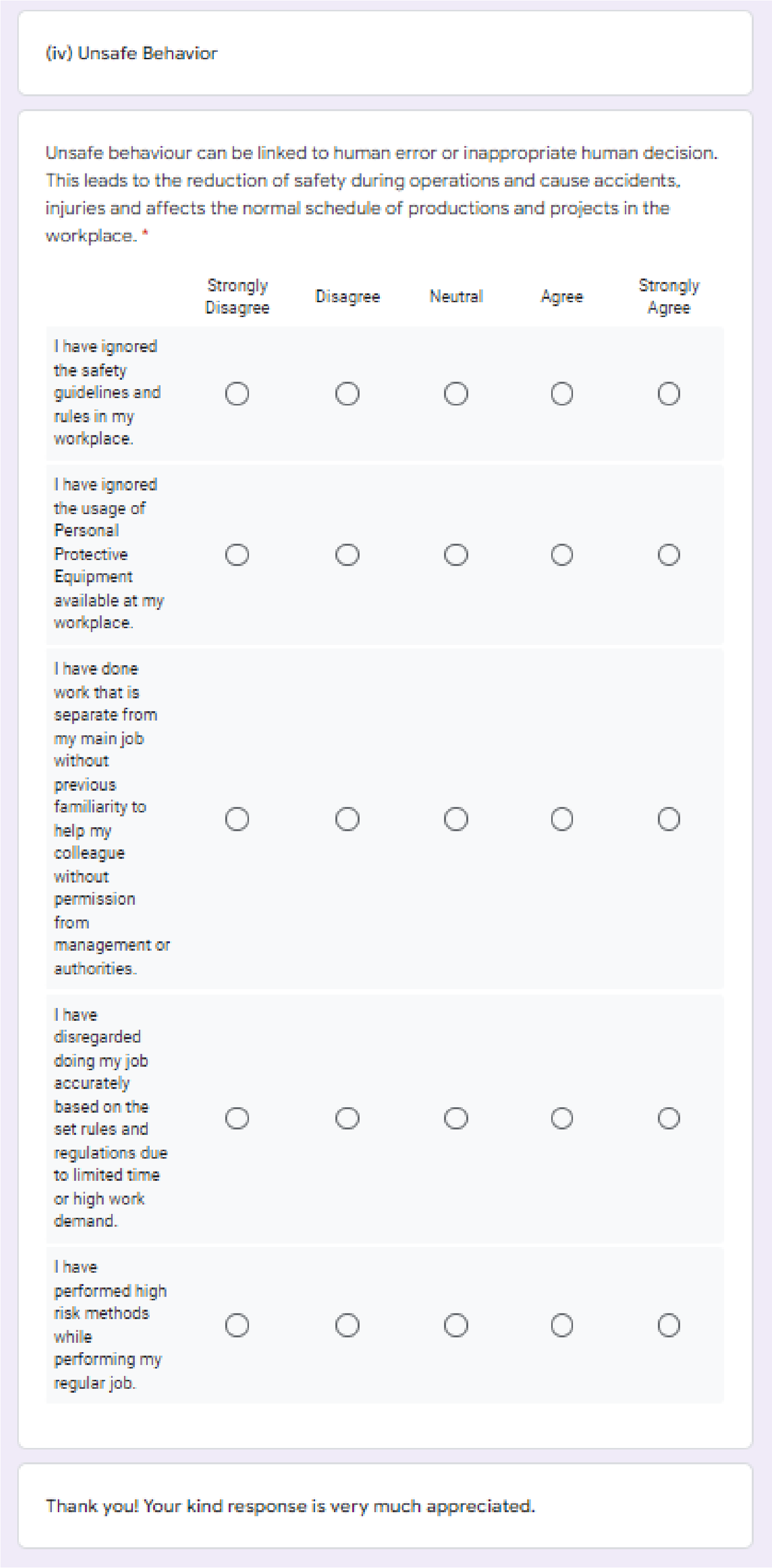
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I know how to perform my job according to the appropriate actions and descriptions.	○	○	○	○	○
I am experienced with the handling of tools and equipment necessarily handled.	○	○	○	○	○
I am well versed with the safety instructions related to my line of work.	○	○	○	○	○
When faced with an unexpected threatening situation, I am stuck on what I should do or who I should tell.	○	○	○	○	○
There are areas I am unsure of about the issues of safety when performing my duties.	○	○	○	○	○



(iii) Workplace Environment

The basic qualities of a reasonable work environment are such as normal surrounding temperature, odourless, uncongested, dustless and peaceful conditions. Some examples of poor working conditions are such as vibrations of the machines and noise above the margin of safety as well as a lack of appropriate lighting that may cause headaches and strains to the workers field of vision as well as insufficient protection such as lack of Personal Protection Equipment (PPE) for example hard hats and protective glasses from physical, chemical and other various hazards that will protect the wearer's body from harm and injury. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
There is a deficiency of suitable equipment in order to carry out my job.	○	○	○	○	○
There is an inadequate amount of team support.	○	○	○	○	○
There is an irregular number of working hours.	○	○	○	○	○
There is an inadequate amount of time given in order to carry out my work.	○	○	○	○	○
There is a poor workplace layout.	○	○	○	○	○



(iv) Unsafe Behavior

Unsafe behaviour can be linked to human error or inappropriate human decision. This leads to the reduction of safety during operations and cause accidents, injuries and affects the normal schedule of productions and projects in the workplace. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have ignored the safety guidelines and rules in my workplace.	○	○	○	○	○
I have ignored the usage of Personal Protective Equipment available at my workplace.	○	○	○	○	○
I have done work that is separate from my main job without previous familiarity to help my colleague without permission from management or authorities.	○	○	○	○	○
I have disregarded doing my job accurately based on the set rules and regulations due to limited time or high work demand.	○	○	○	○	○
I have performed high risk methods while performing my regular job.	○	○	○	○	○

Thank you! Your kind response is very much appreciated.

Appendix 2: Clearance form for Research Questionnaire

Wholly owned by UTAR Education Foundation
(Co. No. 578227-M)
DU012(A)

UNIVERSITI TUNKU ABDUL RAHMAN
LEE KONG CHIAN FACULTY OF ENGINEERING AND SCIENCE
Bachelor of Engineering (Honours) Mechanical Engineering

Dear respondent,
I am an undergraduate student of Bachelor of Engineering (Hons) Mechanical Engineering at Universiti Tunku Abdul Rahman (UTAR) and I am currently conducting a research on:

Study of the Workplace Accidents Caused by Human Error in the Manufacturing Industry using Structural Equation Modeling (SEM)

This research study is a compulsory subject to partially fulfil the requirement of the degree program. This questionnaire is carefully designed to be completed in no more than 15 minutes. This questionnaire focuses on industrial manufacturing companies in Malaysia. The attached questionnaire consists of a series of sections which have a demographic profile and are a measurement of dependent and independent variables of our study.

I would appreciate if you would spend some of your time to complete the enclosed questionnaire based on your own knowledge and understanding. Your cooperation is highly appreciated and thank you for spending your precious time to fill in our questionnaire.

Lastly, your responses will be kept strictly **PRIVATE AND CONFIDENTIAL** as they will and only be used solely in our research purpose.

Supervisor

Name: Mr. Cheong Wen Chiet

Faculty: Lee Kong Chian Faculty of Engineering and Science

Department: Department of Mechanical and Material Engineering

Contact: +603-90860288

Email: cheongwc@utar.edu.my

Student

Name: Natalee Corbett

Faculty: Lee Kong Chian Faculty of Engineering and Science

Department: Department of Mechanical and Material Engineering

Contact: +6012-4416081

Email: nataleec37@utar.edu.my

Section A: Demographic Profile

INSTRUCTION: Please fill up the information below accordingly by placing a tick (✓) in the box of your answer.

1. Company name:

2. Company Location:
   ☐ Johor
   ☐ Kedah
   ☐ Kelantan
   ☐ Melaka
   ☐ Negeri Sembilan
   ☐ Pahang
   ☐ Pulau Pinang
   ☐ Perak
   ☐ Perlis
   ☐ Sabah
   ☐ Sarawak
   ☐ Selangor
   ☐ Terengganu
   ☐ Kuala Lumpur
   ☐ Labuan
   ☐ Putrajaya

3. Company Businesses Size
   ☐ Small Enterprise (Full time employee below 75)
   ☐ Medium Enterprise (Full time employee between 75-200)
   ☐ Large Scale Company (Full time employee more than 200)

4. Type of Industries
   - ☐ Metal Industry
   - ☐ Electrical and Electronics Industry
   - ☐ Chemical Industry
   - ☐ Oil and Gas Industry
   - ☐ Automotive Industry
   - ☐ Machinery and Equipment Industry
   - ☐ Food and Beverage Industry
   - ☐ Rubber Industry
   - ☐ Plastics Industry
   - ☐ Others: ___________________________

5. Position in the company
   - ☐ Technician
   - ☐ Executive
   - ☐ Operator
   - ☐ Engineer
   - ☐ Supervisor
   - ☐ Manager
   - ☐ Specialist
   - ☐ Others: ___________________________

Section B: Measurement of Dependent and Independent Variable

This section and onwards are used to measure the dependent and independent variable in this study.

INSTRUCTION: Please read the statements below attentively and pinpoint your agreement level by indicating the scale that best represent your judgement.

Study of Workplace Accidents Caused by Human Error in the Manufacturing Industry using Structural Equation Modeling

i) Human Error

Human error can be characterised as the lack of proper judgement or appropriate decision-making characteristics in the cognitive process. Human error can be divided into 3 different categories which are skill-based, rule-based and knowledge-based errors. Some of the human qualities that can cause complications in interactions with the workplace environment are such as consciousness, human perception, recollection ability, and rationality.

1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5=Strongly Agree

		1	2	3	4	5
1.	I have started doing my job without bringing the necessary tools due to other mental or physical engagements.					
2.	I have negligently forgotten to carry out one or more stages during or before finishing my job.					
3.	I have removed or turned off the safety system located on the device, equipment or work tools without reason or due to a lack of risk awareness.					
4.	I have performed my job at a speed less or more than my usual speed and failed to carry out my job properly.					
5.	I have tried a new method of carrying out my job based on my own knowledge without enough experience or prior information.					

Adapted from Mohammadfam, I., Mahdinia, M., Soltanzadeh, A., Aliabadi, M.,2021. A path analysis model of individual variables predicting safety behavior and human error: The mediating effect of situation awareness. International Journal of Industrial Ergonomics, 84.

ii) Safety Knowledge

Safety knowledge is the ability of knowing the ways of performing work safely. Safety knowledge can be enhanced by providing workers with safety training which prepares workers with the skills needed to recognise and manage workplace hazards. Workers must also have informal knowledge of industrial profession such as the rules of thumb and skills so that they are well equipped with the knowledge that can be obtained through observation and first-hand experience.

1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5=Strongly Agree

		1	2	3	4	5
1.	I know how to perform my job according to the appropriate actions and descriptions.					
2.	I am experienced with the handling of tools and equipment necessarily handled.					
3.	I am well versed with the safety instructions related to my line of work.					
4.	When faced with an unexpected threatening situation, I am stuck on what I should do or who I should tell.					
5.	There are areas I am unsure about the issues of safety when performing my duties.					

Adapted from Mohammadfam, I., Mahdinia, M., Soltanzadeh, A., Aliabadi, M.,2021. A path analysis model of individual variables predicting safety behavior and human error: The mediating effect of situation awareness. International Journal of Industrial Ergonomics, 84.

iii) Workplace Environment

The basic qualities of a reasonable work environment are such as normal surrounding temperature, odourless, uncongested, dustless and peaceful conditions. Some examples of poor working condition are such as vibrations of the machines and noise above the margin of safety as well as lack of appropriate lighting that may cause headache and strains to the workers field of vision as well as insufficient protection such as lack of Personal Protection Equipment (PPE) for example hard hats and protective glasses from physical, chemical and other various hazards that will protect the wearer’s body from harm and injury.

1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5=Strongly Agree

		1	2	3	4	5
1.	There is a deficiency of suitable equipment in order to carry out my job.					
2.	There is an inadequate amount of team support.					
3.	There is an irregular number of working hours.					
4.	There is an inadequate amount of time given in order to carry out my work.					
5.	There is a poor workplace layout.					

Adapted from Moura, R., Beer, E. Patelli and Lewis, J., 2015. Human error analysis: Review of past accidents and implications for improving robustness of system design, Safety and Reliability: Methodology and Applications, pp. 1073-1082.

Adapted from Anoosheh, M., Ahmadi, M., Faghihzadeh, S. and Vaismoradi, M., 2008. Causes and management of nursing practice errors: a questionnaire survey of hospital nurses in Iran. International Nursing Review, 55(3) pp. 288-295.

iv) Unsafe Behaviour

Unsafe behaviour can be linked to human error or inappropriate human decision, this leads to the reduction of safety during operations and cause accidents, injuries and affect the normal schedule of production and projects in the workplace.

1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5=Strongly Agree

		1	2	3	4	5
1.	I have ignored the safety guidelines and rules in my workplace.					
2.	I have ignored the usage of Personal Protective Equipment available at my workplace.					
3.	I have done work that is separate from my main job without previous familiarity to help my colleague without permission from management or authorities.					
4.	I have disregarded doing my job accurately based on the set rules and regulations due to limited time or high work demand.					
5.	I have performed high risk methods while performing my regular job.					

Adapted from Shakerian, M., Choobineh, A., Jahangiri, M., Hasanzedah, J. and Nami, M., 2019. Is “Invisible Gorilla” self-reportedly measurable? Development and validation of a new questionnaire for measuring cognitive unsafe behaviors of front-line industrial workers. International Journal of Occupational Safety and Ergonomics, 27(3).