Impact of Human Errors on Accidents in the Oil and Gas Industry in Bahrain

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Impact of Human Errors on Accidents in the Oil and Gas Industry in Bahrain

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DEDICATION

First and foremost, I would like to thank God Almighty for giving me the strength, knowledge, ability and opportunity to undertake this research study and to persevere and complete it satisfactorily.

This piece of work is especially dedicated to my dearest wife and my lovely children Ali and Jamal as this achievement and past four years would not have been possible without their support.

DECLARATION

This thesis submitted under the fulfilment of the requirements of the Degree of Doctor of Philosophy at University of Salford. Part of findings in this research were published as refereed conference papers and a refereed conference poster before the submission of the thesis during the PhD studies journey. Appendix 1 presents these publications.

I declare that no portion of the work referred to in the thesis has been submitted in support of an application for another degree of qualification to the University of Salford or any other institution.

Musab Alkhaldi

LIST OF ABBREVIATIONS

API	American Petroleum Institute
BANAGAS	Bahrain National Gas Company
Bapco	Bahrain Petroleum Company
BEDB	Bahrain Economic Development Board
BERA	Business and Economic Research Advisor
BLS	Bureau of Labor Statistics
BNA	Bahrain News Agency
BP	British Petroleum
DNV.GL	Det Norske Veritas and Germanischer Lloyd
DPSA	Development and Production Sharing Agreement
EIA	Energy Information Administration
EIU	Economist Intelligence Unit
EME	Energy and Mineral Engineering
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
HAS	Health and Safety Authority
HSC	Health and Safety Commission
HSE	*Health and Safety* Executive
ICT	Information Communication Technology
ILO	*International Labour Organisation*
INTERTANKO	International Association of Independent Tanker Owners
ISHN	Industrial Safety Hygiene News
KOSHA	Korea Occupational and Health Agency
LNG	Liquefied Natural Gas
MOHR	Ministry of Human Resource
MOL	Ministry of Labour

NASA	National Aeronautics and Space Administration
NEBOSH	National Examination Board of Occupational Safety and Health
NIHL	Noise-Induced Hearing Loss
NIOSH	National Institute for Occupational Safety and Health
NOGA	National Oil and Gas Authority
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NSC	National Safety Council
O&G	Oil and Gas
OAPEC	Organisation of Arab Petroleum Exporting Countries
OBG	Oxford Business Group
OCIMF	The Oil Companies International Marine Forum
OHS	Occupational Health and Safety
OHSMS	Occupational Health and Safety Management System
OPEC	Organisation of the Petroleum Exporting Countries
OSHA	Occupational Safety and Health Administration
OSS	Occupational Safety Section
PPE	Personal Protective Equipment
PwC	PricewaterhouseCoopers
SIO	Social Insurance Organisation
SPSS	Statistical Package for Social Sciences
U.S.	United States
UAE	United Arab Emirates
UK	United Kingdom
UKOOG	United Kingdom Onshore Oil and Gas
UKPIA	The United Kingdom Petroleum Industry Association
UKRIO	United Kingdom Research Information
WBG	World Bank Group
WHO	World Health Organisation

WTO	World Trade Organisation

ABSTRACT

Through the last few decades, occupational accidents had increased in different workplaces around the world. One of the main causes of these accidents is human error. Human error is an improper decision or behaviour of any worker in the workplace. In the Oil and Gas (O&G) industry, human error constitutes as the largest contributor of over 80% of all accidents. Although the O&G industry is a pillar of the economy of some countries like Bahrain, few studies have paid attention to address human error accidents and reduce its occurrence particularly within this industry. Accordingly, this research aims to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan. This aim will be achieved by identifying the current Occupational Health and Safety (OHS) framework in Bahrain and by critically evaluating the challenges related to human errors specific accidents in the O&G industry in Bahrain.

In order to achieve the aim and objectives of the research, a case study strategy and multiple case study design is adopted. Three case studies are selected in refining, distributing and storage units in the downstream. Data collection and data analysis were conducted following mixed methods using semi-structured interviews and questionnaire surveys as primary data collection techniques. 12 semi-structured interviews were conducted with the managerial level in three units. Whilst a total 226 questionnaires were distributed, 163 were received and valid. Content analysis was used to analyse qualitative data. Descriptive statistics through central tendency measures and inferential statistics through Spearman's Rank Order Correlation Coefficient and Mann-Whitney U Test were both deployed to analyse quantitative data. Results indicate that human error accidents have common examples in the O&G industry in Bahrain like overconfidence, ignoring the importance of wearing Personal Protective Equipment (PPE) and carelessness and there are nine challenges that contribute to these accidents. The most critical five challenges from the managerial and operational levels viewpoints are safety training, accidents reporting system, communication, safety implementation and safety leadership. Results reveal also that OHS framework in this industry in Bahrain requires more improvement and compliance with international regulations and best safety practices.

As this thesis develops an action plan, it is a powerful platform for change that focuses on the nine action areas in the developed strategy. This thesis as well gives academics and professionals unique insights and significant understanding of the setting of human error accidents in this industry in Bahrain and the related challenges.

CHAPTER 1: INTRODUCTION

1.1 Introduction

This chapter is the introductory chapter for the overall thesis. It intends to present a general overview on several main aspects of the current thesis. It starts with highlighting the research background and the research justification. Several terms are discussed like accidents, human error and the issue of accidents in the O&G industry in general and in Bahrain in specific. Then, it outlines the aim and objectives followed by a clear discussion on where each objective will be addressed in this thesis. After that, it provides an indication of the scope and limitation of this thesis, the methodological framework, the expected contribution to knowledge, and the structure of this thesis.

1.2 Research Background

The O&G industry is one of the industries that has a strategic importance in the global economy and it is a backbone of the economy of most countries located in the Middle East and other regions worldwide (Higgins & Vernadsky, 2013; Mitchell, Marcel & Mitchell, 2012). Many countries like Bahrain consider the O&G industry as an economic lifeline (Bahrain Economic Development Board BEDB, 2014). In simple expression, the O&G industry is a producer of O&G. This primarily is true but in fact this industry is a complex industry as it comprises of many units and sub-divisions, various operations and processes, and different chemicals and materials (Mondy, 2010). The O&G industry consists of the upstream and downstream (Fanchi & Christiansen, 2016; Robinson & Scott, 2016). The upstream unit embodies exploration, development, drilling, production of crude oil or natural gas, and transportation of O&G to the refinery. Whereas, the downstream unit involves processing, refining, storage, distribution and marketing of petroleum products to domestic and industrial consumers. Figure 1.1 shows the upstream and downstream in the O&G industry.

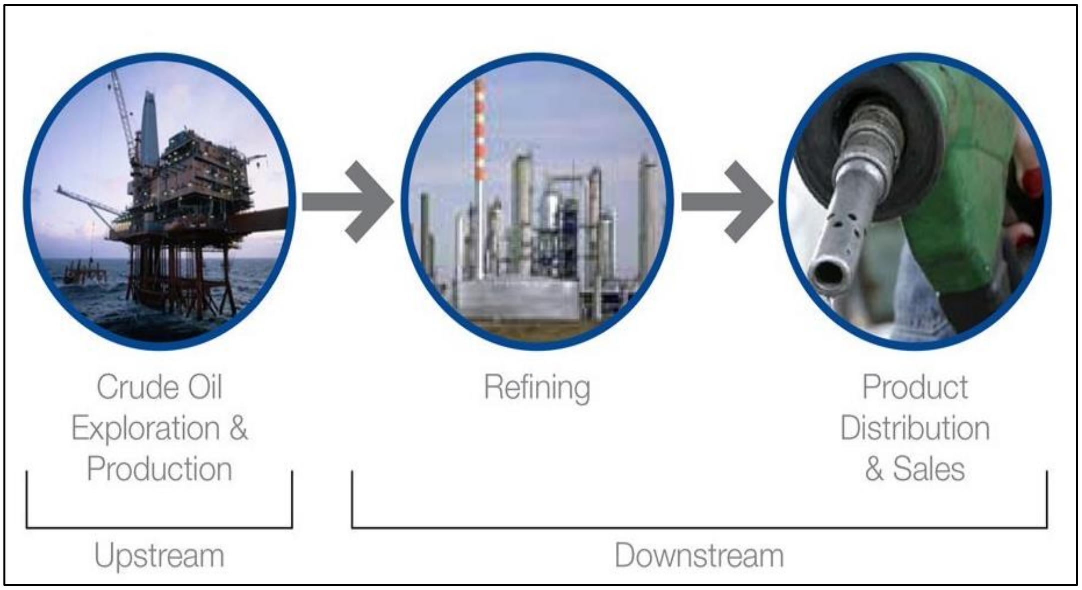

Figure 1.1: The Oil and Gas Industry, (Source: Fuels Europe, 2019)

Over four billion metric tons of oil are produced annually around the world and the Middle East region approximately holds one third of this production (The Natural Resource Governance Institute, 2015). The global O&G exports in 2017 were US$1.815 trillion that was the world's second most valuable exported product (Workman, 2018). The O&G industry is also a key part of world energy (Mitchell et al., 2012; Zoveidavianpoor, Samsuri, & Shadizadeh, 2012). The O&G industry has grown rapidly over the past 40 years and it is expected to grow more with a strong demand (Witter, Tenney and Clark 2014; Mattia, 2013). Despite the fact that the recent rapid development projects of this industry have provided a wealth of new jobs and a burst of economic vitality for various countries, these benefits are at cost (Det Norske Veritas and Germanischer Lloyd DNV.GL, 2016; Paraventi, 2014). First, the price of O&G is currently a great deal of uncertainty, therefore, maintaining a high level of profits, reducing costs and preventing accidents that will bring more additional costs to the workplace are of the most important and critical elements going forward at the moment (Torp, 2015). As well as, the O&G industry nowadays is confronting a sharp focus on cost and demands for uptime (Christ, 2015; DNV.GL, 2016). Moreover, the O&G industry is a high-risk venture that depends largely on capital and technology while unfortunately it could pose unpredictable consequences to workers and workplace (Ernst & Young, 2013). Accordingly, the current increasing in demand means that workplaces of the O&G

industry will increase workplace activities and this will result in increasing the probability occupational accidents (Lawyers and Settlements, 2011).

On the other hand, globalisation nowadays is causing profound and complex technological, cultural, economic, institutional, social, legal, and environmental changes and alterations (Hassanzadeh, 2013; World Bank Group WBG, 2011). These changes are introducing new opportunities as well as risks in industries and workplaces. This means that these changes are affecting the OHS in many industries (Hilderink, Hueynen & Martins, 2009; Alli, 2008). Chauhan (2013) indicated that the O&G industry is not an exception as it deals with risky materials. Based on that, there is a growing concern for safe workplace and healthy environment. For instance, Lucchini & London (2014) highlighted the importance of integrating OHS aspects in all social and economic developments, both at the global and country levels. Accordingly, the need for "industrial safety strategy" is raised particularly with the advancement of scientific development along with high numbers of industrial accidents. Moreover, Zoveidavianpoor et al. (2012) claimed that awareness should be provided for industrial safety in the O&G industry in such areas like risk evaluation, development of remediation and replacement techniques.

Safety concept is becoming increasingly one of main criteria of competitive advantage in the current fierce business environment (Hassanzadeh, 2013; Marcella, Pirie & Doig, 2011), in term of reduced costs, being in line with the international rules and regulations and being able to identify the elements required to increase the service competitiveness (Hassanzadeh, 2013). Safety is considered as a necessary system property that ensures that the probability of the undesired events that could harm workers, public or environment is acceptably low (Besnard & Hollnagel, 2012). In contrast, risk is a continuous predicament that exacts a great toll on workers and their employers during an occupational accident. Occupational accidents result in loss of man-hours, output, reputation, product and service quality and low workers morale in addition to the grave consequences on workers' productivity (Harms-Ringdahl, 2013; Agwu, 2012). Occupational accidents also can significantly affect the workers and their families and friends as well (El Bouti & Allouch, 2018). Thus, industrial safety is not a dislike of risks and hazards; instead, it is an aptitude of controlling hazards inherent to work processes or related to the environment.

Therefore, it is a challenging issue for any company to prevent occupational accidents effectively, in particular for the O&G industry. After discussing the research background, it is important to move the discussion to research justification.

1.3 Research Justification

The accidents rates have increased alongside the industrial revolution and the rapid globalisation (El Bouti & Allouch, 2018). The O&G industry is one of the risky workplace suffers from adverse events and accidents. Mulloy (2014) indicated that as the extraction activities in the O&G industry are growing rapidly, occupational accidents would bring along with them. The following sub-sections discuss the accident rate, accidents cost, causes of these accidents in the O&G industry and human error in the O&G industry. After that, challenges in the O&G industry in Bahrain and human error in this industry in Bahrain are also explained.

1.3.1 Accident Rate in the Oil and Gas Industry

As the O&G industry faces a number of evolving and numerous types of risks and hazards that could lead to serious accidents, the fatality rates for workers in the O&G industry have historically been higher than the rate of other workplaces (Mall, 2016; Mason, Retzer, Hill & Lincoln, 2015). Witter et al. (2014) indicated that the occupational fatality rate in the O&G industry is higher than other industries. According to Mason et al. (2015), the fatality rates in the O&G industry have increased by 27.6% between 2003 and 2013. The Health and Safety Executive (HSE) (2012) in United Kingdom (UK) pointed the total of accidents and dangerous occurrences in 2012/13 were 47 accidents compared to 36 in 2011/12 and 42 in 2010/11. The United States (U.S.) Bureau of Labor Statistics (BLS) noticed that the fatality rate of the O&G industry in U.S. is 25.0 deaths per 100,000 workers which remains above the rate for all U.S. workers which is 3.7 per 100,000 workers (BLS, 2015).

Based on the Pittsburgh Post-Gazette states reports, the fatality rate in the O&G industry are the highest they have been since the U.S. BLS began keeping track in 1992 (BLS, 2013). Figure 1.2 showed the result of this report by showing the increasing trend in the O&G industry fatalities in relation with the increased employment.

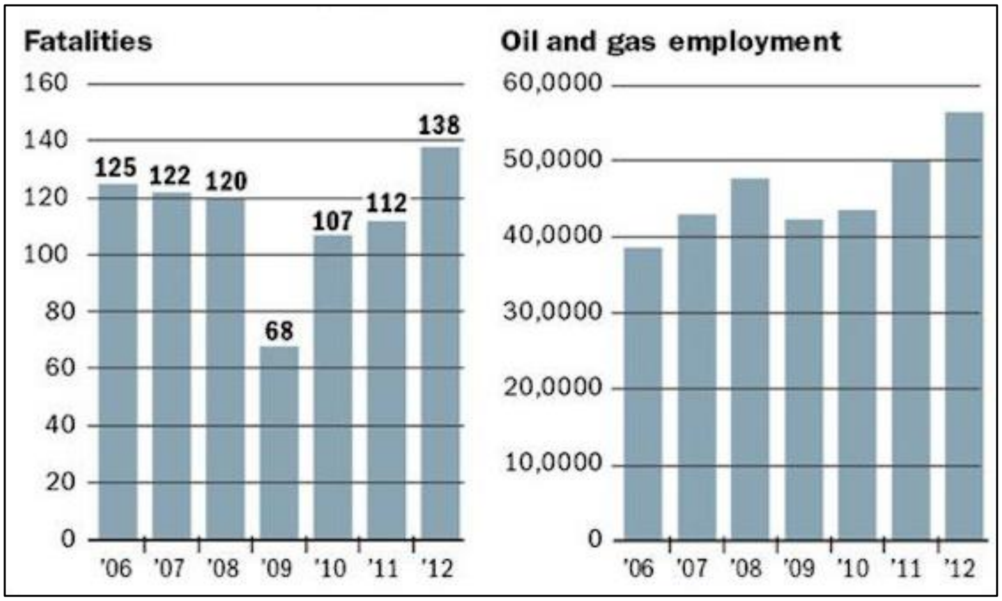

Figure 1.2: Fatalities and Employment in the O&G Industry in the U.S., (Source: BLS: 2013)

On the other hand, the U.S. BLS (2014) reported the fatalities in the private sector in the O&G industry and in the mining industry as a whole between 2003 and 2011 as shown in Figure 1.3.

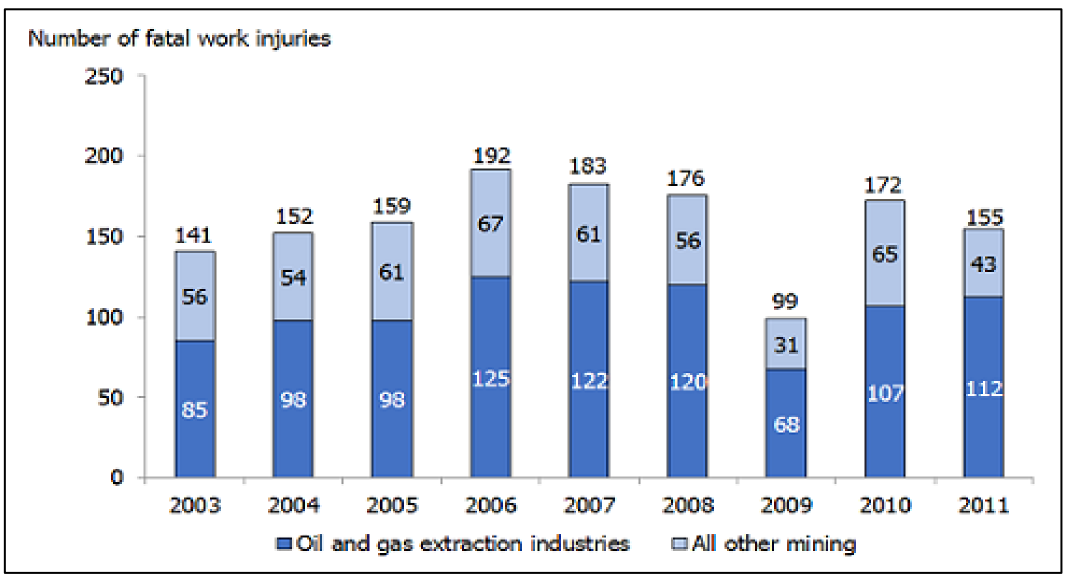

Figure 1.3: Fatalities in the Private Sector in the O&G Industry in the U.S., (Source: BLS: 2014)

Particularly, in 2011 there were 112 fatalities in which 51 fatalities in transportation accidents, 26 fatalities in contact with objects and equipment, 12 fatalities in fires or explosions and the remaining fatalities in multiple fatality events (BLS, 2014). Moreover, there were 529 fatal injuries in the O&G industry between 2007 and 2011. However, it can be conclude that this number has an increasing trend since 2009. Whereas based on Figure 1.3 the total of fatalities in the O&G industry is 404 and particularly 110 fatalities in transportation accidents, 88 fatalities in contact with objects and equipment, 93 fatalities in fires or explosions and the remaining fatalities in multiple fatality events (BLS, 2014).

However, the accident rate of the O&G industry in some countries is included in the accident rate of manufacturing sector as a whole. For example, in UK the accident rate for manufacturing sector that includes the O&G industry was 23% in 2014. It was less than a quarter when UK was ranked as the 11^{th} largest manufacturing nation around the world (HSE, 2014). Table 1.1 shows the yearly accidents rate in UK in this industry from the total yearly accident rate in the country. This table shows also that this accident rate has a decreasing trend due to several actions taken to reduce the rate.

Table 1.1: Accident Rate in Manufacturing Sector in UK, (Source: HSE, 2014)

Year	**1998**	**2002**	**2006**	**2010**	**2014**
Accident Rate in the Manufacturing Sector from the total Accident Rate in UK	33%	31%	28%	26%	23%

In Malaysia, this rate was around 20% in 2015 and this rate declined in comparison to 35% in 2009 (Ministry of Human Resource MOHR, 2016). This rate is shown in Table 1.2.

Table 1.2: Accident Rate in Manufacturing Sector in Malaysia, (Source: MOHR: 2016)

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Accident Rate in the Manufacturing Sector from the total Accident Rate in Malaysia	35%	33%	30%	29%	32%	26%	20%

In this regard and based on Baker Hughes & M-I Swaco (2011) which is an international service provider for the O&G industry, the Middle East Region was the third high region in the number of occupational accidents in the O&G industry in December 2010 as shown in Figure 1.4.

Region	December 2010 Land	December 2010 Offshore	November 2010 Land	November 2010 Offshore	December 2009 Land	December 2009 Offshore
CANADA	**396**	**1**	**420**	**0**	**310**	**2**
EUROPE	**46**	**48**	**36**	**53**	**32**	**46**
Germany	7	0	3	1	4	1
Italy	3	1	5	2	3	1
Netherlands	2	5	2	5	3	2
Norway	0	19	0	22	0	22
Poland	6	1	2	0	3	0
Romania	13	0	11	0	7	0
United Kingdom	0	20	2	20	0	14
Others	15	2	11	3	12	6
MIDDLE EAST*	**237**	**40**	**238**	**42**	**231**	**41**
Abu Dhabi	8	4	8	4	7	3
Iran	54	17	54	17	55	17
Oman	41	0	43	0	47	1
Saudi Arabia	52	8	55	11	55	12
Syria	31	0	30	0	19	0
Turkey	10	1	10	1	6	0
Others	41	10	38	9	42	8
AFRICA	**126**	**35**	**126**	**32**	**120**	**23**
Algeria	24	0	24	0	27	0
Egypt	48	9	47	12	37	12
Libya	15	1	14	1	15	1
Nigeria	4	7	8	12	4	4
Sudan	25	0	21	0	24	0
Others	10	18	12	7	13	6
LATIN AMERICA	**313**	**71**	**314**	**79**	**276**	**73**
Argentina	61	0	72	0	55	0
Brazil	34	41	34	41	32	34
Colombia	54	0	54	0	31	0
Mexico	60	20	64	23	98	24
Venezuela	76	6	63	11	38	11
Others	28	4	27	4	22	4
ASIA-PACIFIC	**172**	**125**	**170**	**122**	**173**	**112**
Australia	7	9	6	7	7	10
China, offshore	0	32	0	29	0	29
India	82	30	81	29	75	29
Indonesia	45	15	44	17	47	11
Malaysia	0	8	0	10	0	13
Myanmar	2	0	1	0	3	2
Pakistan	15	0	16	0	18	0
Thailand	3	9	2	9	5	10
Vietnam	0	14	0	15	0	8
Others	18	8	20	6	18	0
Total	**1,290**	**320**	**1,304**	**328**	**1,142**	**297**

*No data available for Iraq. *Sources: Baker Hughes & M-I Swaco*

Figure 1.4: Fatalities in the Oil and Gas Industry in Different Regions and Middle East, Source: (Baker Hughes & M-I Swaco, 2011)

Apart from that, the number of occupational accidents that occur in the Gulf Cooperation Council (GCC) countries is an issue of contention (Zekri, 2013). As a result, it is too difficult to comment on the relative frequency and severity of accidents in the O&G industry and even other types of industries for most GCC countries. In United Arab Emirates (UAE), Dubai Municipality recorded 39 work-related deaths in 2005 in the industrial sector while an investigation by Human Rights

Watch revealed that an official at the Indian Consulate in Dubai recorded 61 work-related deaths in 2005 in the industrial sector (Zekri, 2013). In 2003, the occupational fatality rates per 100,000 workers were as 8.3 in Bahrain, 7.9 Saudi Arabia, 7.1 in Oman and 5.9 in Kuwait (Hamalainen, Takala & Saarela, 2009). These rates showed that Bahrain was the highest fatality rate among these the three countries. Moreover, the fatality rate in Dubai in 2009 was 5.6 people per 100,000 workers which was higher than the UK rate of 3.7 per 100,000 people in the same year (Witt and Birt, 2014). On the other hand, the fatality rate in Bahrain in 2007 was 7.0 per 100,000 workers based on International Labour Organisation (ILO) statistics and was more than 9.0 in 2007 according to Eurostat (Neave, 2010).

Based on these statistics, there is a rising tide in Bahrain in the number of occupational accidents in comparison to the declining trend in UK and Malaysia as it is shown in Table 1.1 and Table 1.2 respectively. Statistics of Ministry of Labour (MOL) showed that the number of occupational accidents in all industry types almost doubled between 2006 and 2008 (Alaradi, 2010). Based on Labour and Social Development Ministry statistics, the total number of occupational accidents in Bahrain in 2017 was 388 accidents in which the Gulf Daily News in Bahrain reported that this total was higher than 2016 by 14% (Unnikrishnan, 2018). On the other hand, MOL pointed out that the total number of occupational accidents between 2005 and 2009 increased by more than three times (Alaradi, 2010). The accident rate of the O&G industry in Bahrain is included in the accident rate of manufacturing sector in Bahrain as a whole shown in Table 1.3.

Table 1.3: Accident Rate in Manufacturing Sector in Bahrain (Source: MOL, 2018)

Year	**2014**	**2015**	**2016**	**2017**
Accident Rate in the Manufacturing Sector from the total Accident Rate in Bahrain	21%	20.6%	21.8%	27%

As these accidents have considerable costs on workers, workplace and environment, the next section explains that.

1.3.2 Accidents Cost in the Oil and Gas industry

Accidents in the O&G industry are not just matters of health rather accidents are much closed to economics (Dorman, 2000); thereby, considering the economic perspective is an important issue (Bolu, 2011). The cost of an accident is the direct (initial) cost which appears directly from the accident itself plus the indirect (consequential) cost which arises indirectly as a result of the accident and it is higher than the direct one (National General Certificate Unit, 2015). Similarly, Mossink and De Greef (2002) indicated that regardless the total amount of the direct cost of an accident, the total amount of the indirect cost would exceed what may or may not be visible and subject to insurance coverage. A conservative estimate is that for $1.00 of direct accident costs equals to at least $3.00 of indirect costs; however, other studies indicated the hidden cost is 3 to 5 times more than the direct costs (Manuele, 2013). Undoubtedly, accident costs are linked to the economy, workplace, employees and society. The American Chemistry Council (ACC) indicated that the average of major historical accidents in chemical and hydrocarbon processing industries like the O&G industry resulted in injuring or killing hundreds of people, contaminating the environment and losing in greater than $8 billion of a property (Honeywell International Inc, 2010). However, the actual cost is more than this number when associated costs are considered like cost of business interruption, clean-up, legal fees, fines and losses of market share.

On the other hand, National Safety Council (NSC) (2000) reported that the costs of workplace accidents in U.S. in 1999 were $64 billion wage and productivity losses, $20 billion medical costs, $34 billion administrative cost, $4 billion fire & motor vehicle damage and 125 million days lost. On average, the cost per death was $940,000 while it was $28,000 per disabling injury. Wright, Lancaster, Jacobson-Maher, Talwalkar & Woolmington (2000) have lunched “Good Health and Safety is Good Business” campaign and have concluded that every year the total cost of accidents is between $4.5 billion and $8.7 billion including between $1.22 billion and $4.98 billion for the damages to equipment and the overall property. Based on the Health and Safety Authority’s (HSA) (2006) report in Ireland, the total number of reported occupational accidents in 2004 that resulted in three days absence was 45,550. It reported also that the average cost of an accident was $11,800 for median losses including $3,550 for extra salary costs averaging approximately, $2,000 for productivity losses, $2,360 for repair costs and $12,000 for court costs.

However, the cost of accident and the extent of impact vary from one industry to another based on the activities carried out. In the world history, there are several examples of major accidents in the O&G industry where thousands of employees lost their life. The Bhopal Gas plant disaster that was in India in 1984 resulted in losing about 25 tons of the deadly gas that covered over approximately 30 square miles forming a toxic cloud that floated across the city of Bhopal (Rajkumar, 2017; Mishra, Samarth, Pathak, Jain, Banerjee & Maudar, 2009), 10,000 of killed people, 500,000 of injured people and large number of killed cattle. It is considered as the worst industrial disaster (Jahangiri, Hoboubi, Rostamabadi, Keshavarzi & Hosseini, 2015). However, still this disaster is causing health problems like febrile illnesses, respiratory, neurological, psychiatric and ophthalmic symptoms (Mhaske, Awasthi, Saawarn, Ragavendra, Gouraha & Tomar, 2014).

Additionally, Piper Alpha disaster as the world's worst offshore O&G platform disasters that was in the North Sea, UK in 1988 resulted in 167 deaths of workers and almost $3.4 billion for damages cost (National Aeronautics and Space Administration NASA Safety Center, 2013). In general, HSE (2000) summarised that the total costs of an accident in the O&G industry for example like Piper Alpha were more than $2.7 billion of which $102 million was indirect cost in addition to 167 of deaths while in comparison the total cost of 7000 accidents in motor vehicle repair industry yearly was $337 million which represented by $6,800 for each garage. Apart from that, in 1991 Kuwait, as one of GCC countries, experienced the largest oil spill in the world and consequently this had a considerable impacts and costs on the country. For instance, over 600 oil wells were damaged and ten million barrels of crude oil were spilled into the Arabian Gulf (NASA, 2001). More than half of the damaged wells were in the Greater Burgan oil fields which was the second largest oil reserve worldwide (Seacor, 1994). This oil spill also had adverse consequences on the natural ecosystems in Kuwait like water birds, animal, fishery and plant life (Tutton, 2010). This staggering number of damaged wells required eight months of round-the-clock work before they were finally extinguished (Babcock, Karle, Knight, Lattier, Moore & Wilbur, 2017).

Based on that, the cost of accidents in the O&G industry in Bahrain and other GCC countries is considerable. As Bahrain is a small country that depends mainly on this industry for generating revenues, the volume of the direct and indirect costs of such accidents in the O&G industry will have more critical effects on it. However, calculating the direct and indirect costs of accidents in the O&G industry in Bahrain and many developing countries is hard because it requires a specific compensation and social security systems to generate special economic calculation (Hamalainen et al., 2009). Thus, accident cost is one of challenges that are facing the O&G industry nowadays in Bahrain. The causes of accidents in the O&G industry are explained in the next section.

1.3.3 Causes of Accidents in the Oil and Gas Industry

Many built-in health and safety risks may appear in the O&G industry across all different levels from the exploration and extraction activities till the production of O&G derived products (Torp, 2015; Achaw & Boateng, 2012; Rashid, 2010). For instance, heat, noise, electricity, slippery surfaces, lifting, lowering, carrying, pushing and pulling are major examples of these risks. El Bouti & Allouch (2018) pointed that currently the O&G industry confronts with a number of evolving and different sets of risks and hazards that could lead to accidents in the workplace. Therefore, identifying the main causes is a central prerequisite element for instituting preventive actions (Unnikrishnan, Iqbal, Singh and Nimkar, 2015). Various accidents and causes have been recorded in the systems in the O&G industry (Rural Planning Services Group, 2010).

According to Pitblado & Nelson (2013), ineffective safety management programs in the O&G industry were behind the recent ongoing series of accidents. Further, Christ (2015), National Institute for Occupational Safety and Health (NIOSH) (2015), Paraventi (2014), Lawyers and Settlements (2011) and Intersec (2009) have confirmed that there is a relationship between the increase in accident rates and the increase in the number of active drilling and workover rigs especially during the current continuous increasing demand in the O&G industry. Lawyers and Settlements (2011) expressed that accidents are almost inevitable in this industry regarding the high numbers of people employed and the nature of drilling process. In other words, the higher employment of inexperienced workers and the usage of all available equipment to carry out this load even by older rigs that have lower safeguards are the main causes of accidents in the O&G industry. Further, Bhavsar, Srinivasan & Srinivasan (2015) indicated that cognitive challenges faced by process workers during their interactions with the process and decision making were behind this domination.

On the other hand, earlier authors like Anderson (2005) found that poor training programmes, inadequate maintenance plans, poor supervision, ineffective hazard identification measures and inadequate auditing strategies are the main causes of accident in the O&G industry. While from another point of view, the critical cause of accidents in the O&G industry is the unique job requirements of this industry which is characterised by a very labour-intensive (Roth, 2006). This means that workplace activities and processes in this industry depend heavily on workers. For examples, some activities require work overtime, outdoor works in remote places in all types of weather while other activities are hard like standing for long time, lifting relatively heavy equipment and climbing and stooping to work with oily and dirty materials and objects (Rid & Retzer, 2017). Nevertheless, Mattia (2013) indicated that most of accidents in the O&G industry were resulted mainly from human error. Likewise, Torp (2015) and Bhavsar et al. (2015) confirmed that the dominant contributor of over 80% of all the O&G industry accidents was human error. Figure 1.5 summarises the causes of accidents in the O&G industry.

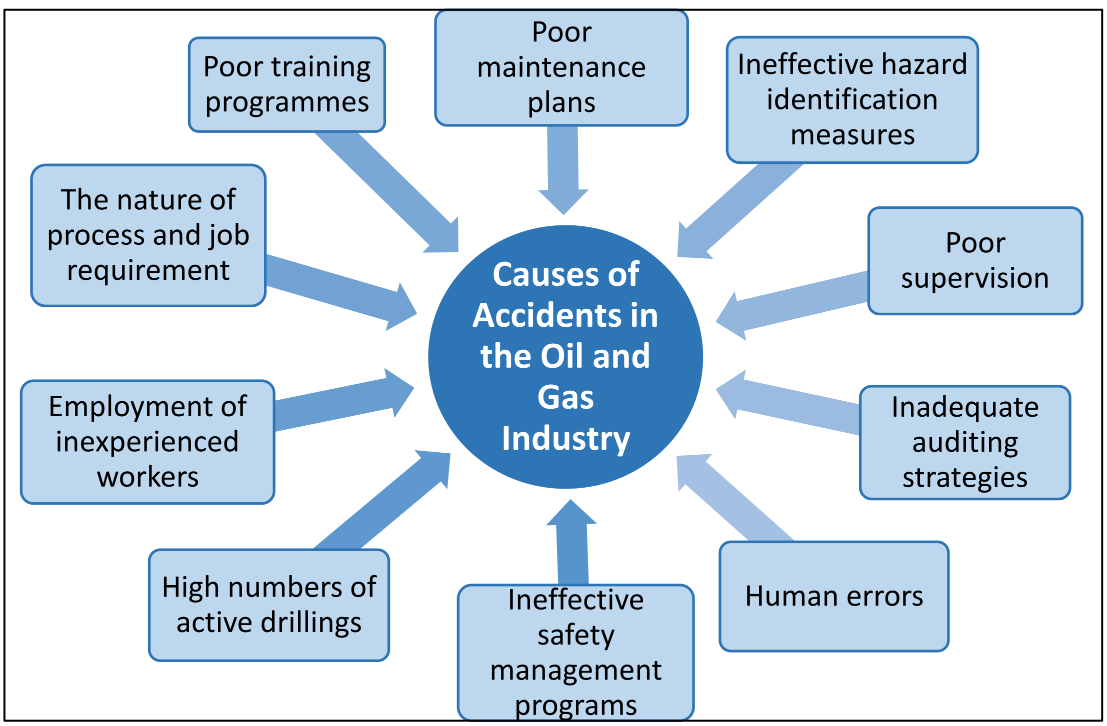

Figure 1.5: Causes of Accidents in the Oil and Gas Industry

1.3.4 Human Error in the Oil and Gas industry

Human error constituted as the largest cause of accidents of over 80% of all accidents in the O&G industry (DNV.GL, 2016; Torp, 2015; Bhavsar et al., 2015). According to National Offshore

Petroleum Safety and Environmental Management Authority (NOPSEMA) in Australia (2018), human error is a failure in executing a planned action to reach a desired result. This authority presented human error in Figure 1.6.

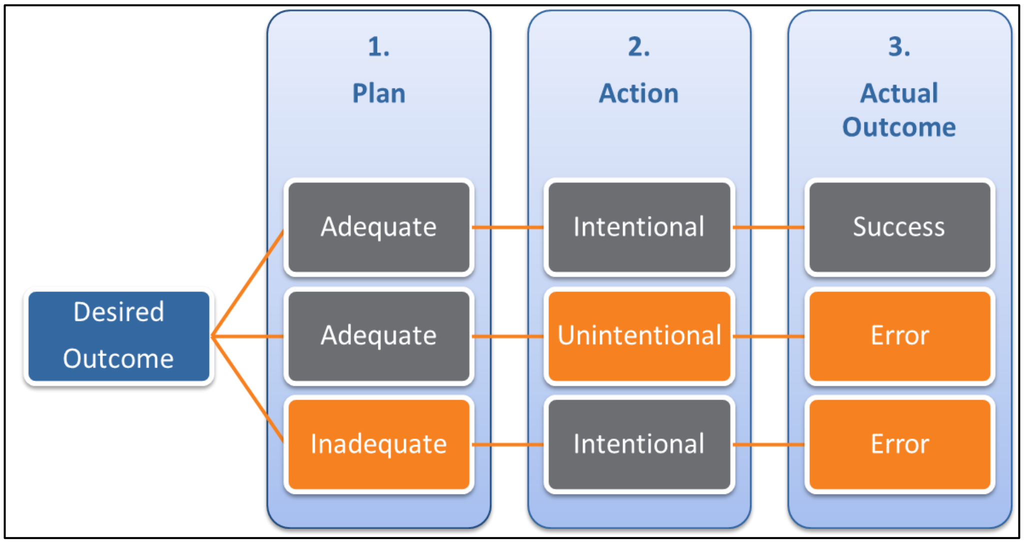

Figure 1.6: Human Error Definition, (Source: NOPSEMA, 2018)

HSE (2005) defined human error as an unintentional action or decision that leads to undesirable consequences. Jahangiri et al. (2016) indicated that the undesirable consequences directly affect safety performance system. Various errors can be identified everywhere because of human nature (Manchi, Gowda & Hanspal, 2013). Mattia (2013) interpreted human error as a natural result that happened when there was a considerable gap between human capabilities and the job requirement in a workplace. In addition, Zeng, Tam & Tam (2008) claimed that human errors are unsafe acts that break the predefined hazard control and job procedures which the workers have been trained or informed on it previously and these acts potentially cause an accident. Lawyers and Settlements (2011) argued that these accidents in the O&G industry typically occurred due to worker's carelessness or recklessness, workers postpone the equipment maintenance or repair and worker's misunderstanding. Based on the recorded accidents in the World Offshore Accidents Database, unsafe act/no procedure is the largest contributor to human error (Christou & Konstantinidou, 2012). Figure 1.7 shows human error in the World Offshore Accidents Database.

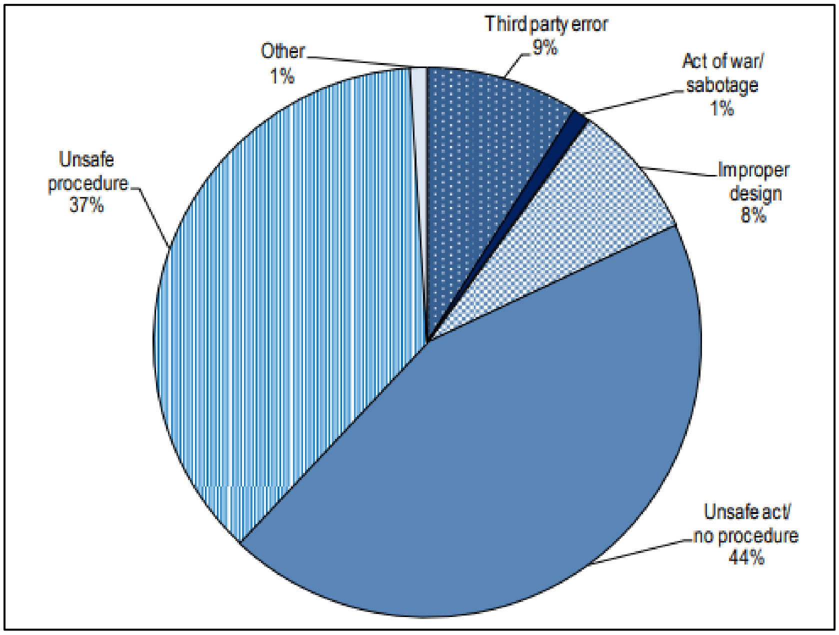

Figure 1.7: Human Error Accidents in the World Offshore Accidents Database (Source: Christou & Konstantinidou, 2012)

Aside from all that, Bhavsar et al. (2015) found that the available resources targeted to address human error and safety issues in this industry are sophisticated for only design stage while other stages remain unclear. Clark, Verity, Wheeler and Landau (2013) and Achaw and Boateng (2012) have asserted that the pace of improvement in the O&G industry has stalled in the last few years even if this industry started to adopt some safety-related programmes and systems. Moreover, Mattia (2013) and Stanton and Wilson (2004) asserted that most of the exploratory attentions and human factors practice and standards were allocated mostly to investigate the Nuclear and Aviation industry but not the O&G industry. Mattia (2013) stated that most of human error studies have emanated from the nuclear industry while the O&G industry still require more serious actions as these techniques of Nuclear and Aviation industries cannot be directly applied to the O&G industry even if there are some similarities. Patel, Sherratt and Farrell (2012) found that human error concept and safety management are highly exploited in the construction industry only. Therefore, DNV.GL (2016) indicated that a holistic risk management approach in the O&G industry is required to prevent major accidents while Pitblado and Nelson (2013) confirmed the importance of human-system integration methods substantially in this industry. Moreover, Mattia (2013) and Motorola Solutions (2014) have deduced that paying attention continuously to improve safety simultaneously with economics in the O&G industry is required essentially.

On the other hand, Risktech (2014), as an independent specialist risk management consulting and training company in UK, indicated that addressing human error and addressing human factors are fundamental in the O&G industry to reduce risks, reduce the potential of occupational accidents, ensure the OHS of workers and workplace and increase the operational efficiency and maintainability. It pointed out that addressing these two principles also contributes to the reduction in cost in the O&G industry especially as any accident in this industry can lead to a considerable cost. Risktech (2014) described the cost of addressing human error and human factors in three lifecycle strategies. These strategies are 'doing nothing strategy', 'reactive strategy' and 'proactive strategy'. The 'do nothing' strategy explains that if the human factors issues are not addressed, the cost will increase rapidly over the lifecycle of the system. The 'reactive strategy' explains that if the human factors issues are addressed in response to a particular matter, the cost will be less aggressive yet increasing manner. While the 'proactive strategy' explains that if the human factors issues are addressed from the beginning, the cost will decrease and be the lowest. Figure 1.8 illustrates these three strategies. Based on this figure, the cost of anticipating human factors issues in early stages is the lowest compared to other strategies.

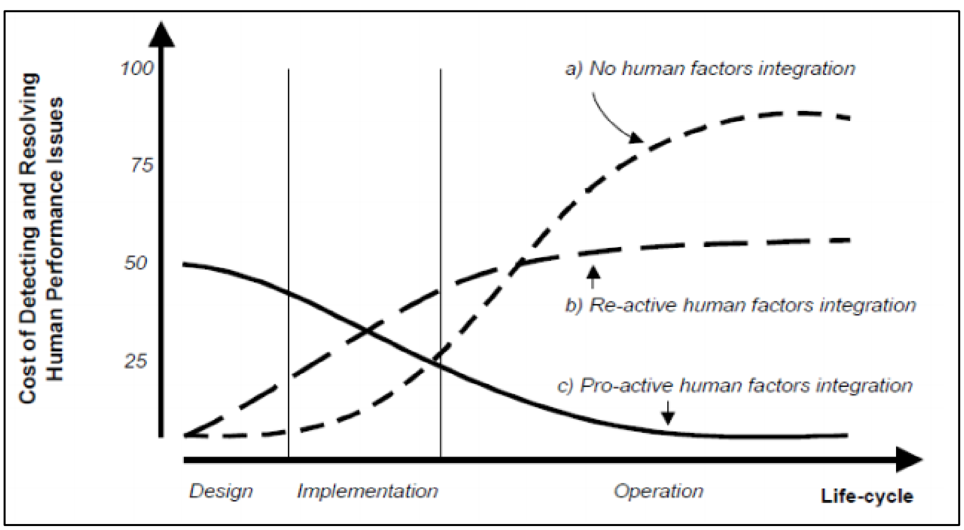

Figure 1.8: The Relation Between Cost and Addressing Human Error and Human Factors, (Source: Risktech, 2014)

After discussing human error in the O&G industry in general, it is important to discuss human error in the O&G industry in Bahrain. The next section provides this discussion.

1.3.5 Human Error in the Oil and Gas Industry in Bahrain

In Bahrain, human error in the O&G industry is also the dominant cause of accidents. Freije (2015), Naser (2011), De Mora, Tolosa, Fowler, Villeneuve, Cassi & Cattini (2010), De Mora, Fowler, Wyse and Azemard (2004), Madany, Jaffar and Al-Shirbini (1998) and Madany, Al-Haddad, Jaffar and Al-Shirbini (1994) have remarked that some mistakes during operational and maintenance activities that were done by workers in the O&G industry in the coastal areas of Bahrain were the primary causes of accidents. Further, Alaradi (2010) found that workers' mistakes are behind hindering several improvements in this industry. Salminen (2011) expressed that educational level, culture factors and language skills are the causes of most occupational accidents in Bahrain, Oman and UAE as the majority of workers are foreign employees. Naser (2011) concluded that Bahrain is under a permanent threat from the O&G industry as Bahraini ports and oil terminals are at high risk of major oil spill accidents.

As human error is one of the main causes of accidents in the O&G industry in Bahrain, the Labour Market Regulatory Authority (2015) defined several procedures to be handled by SIO regarding the compensation for occupational accidents in Bahrain with the following criteria:

- If the worker is dead or has an injury within an accident in his workplace, the employer must inform three parties upon its occurrence within 24 hours. These parties are the nearest police station, the Ministry of Labour and the Ministry of Health. Important information like the name of the injured worker, his occupation, nationality, and address, a description of the accident and the related reasons and actions taken to rescue or treat this worker should be clearly given to these parties.
- In the case of injury, the injured worker should be treated in one of the governmental healthcare centre or any other treatment institutions based on employer's discretion. The employer is the one who is responsible for all treatment costs from the medications, the transportation expenses, the rehabilitation services to the cost of the required prosthetics

if necessary. In the case of disagreement on the costs of treating this worker, the specified Medical Committee appointed by the Ministry of Health will settle that by issuing an estimated charge based three criteria. These criteria are whether the worker suffers from an occupational accident or not, the percentage of impact on injured worker or disability and the duration of treating the injured worker.

- On top of that, the injured worker can submit a grievance against any decision issued within 15 days after issuing this decision in writing. Accordingly, an Appellate Medical Committee will be formed to examine the grievance submitted against the issued decision. During the treatment period, this worker will receive his wage. If the treatment duration requires more than 6 month, this worker will receive half of his wage until his recovery or until his disability is evidenced.

- On the other hand, in the case of death, the compensation will be transferred to heirs. In both cases, the compensation will not be applied in three situations. These situations are when the worker injures himself deliberately, when the worker was under apparent influence of alcohol or drugs, or when the worker breaks the predefined OHS standards and rules.

In 2002, Decree-Law number (33) of trade unions Act 2002 was issued to include all workers under the General Federation of Bahrain Trade Union (Legislation and Legal Opinion Commission, 2019). Based on this law, all workers in the O&G industry in Bahrain are belonging to this union. This union tends to protect the legitimate rights of workers, defend their interests, and improve working conditions. Additionally, it focuses on increasing the level of health, economic and social development of workers and their belongings (Legislation and Legal Opinion Commission, 2019). On the other hand, currently this union does not have the legal power to ensure OHS aspects in the companies in Bahrain especially in the O&G industry and it does not have specific procedures to defend on workers' rights in the case of an accident.

Having this discussion, it is important to present the challenges in this industry in Bahrain. The next section describes that.

1.3.6 Challenges in the Oil and Gas Industry in Bahrain

Globalisation and market trend pursue various rapid developments and installation in GCC countries (BEDB, 2013). Thus, several specific challenges present in the O&G industry in Bahrain. For example, occupational accidents statistics in the O&G industry are not standardised and not reliable in Bahrain due to lack of proper recording and notification systems (Hamalainen et al., 2009). Indeed, these statistics do not contain many data about the root causes of accidents and do not reflect the actual situation of OHS in Bahrain (Matooq & Suliman, 2013b; AlBanna, 2002). In addition, these statistics are seldom recorded because of recording bias (Matooq & Suliman, 2013a; Barss, Addley, Grivna, Stanculescu & Abu-Zidan, 2009). Moreover, Bahrain is not familiar with their safety problems and OHS obstacles clearly (Hamalainen et al., 2009; Roudsari & Ghodsi, 2005).

Besides, OHS framework and enforcement structure in Bahrain needs redesigning plans in the national framework, legislations and enforcement policies due to the lack of standardisation, consistency and fairness (Matooq and Suliman, 2013b; Alaradi, 2010). Matooq and Suliman (2013b) found a low trust between MOL and Social Insurance Organisation (SIO). Nevertheless, Bahrain as a petroleum country has a limited research on the region's long-term geo-economic significance (Matooq & Suliman, 2013a; AlBanna, 2002). Further, Barss et al. (2009) indicated that recent rapid economic development projects that have been undertaken in GCC countries have outstripped the capacity of government to train and set up industrial hygienists and safety supervisors to ensure and maintain OHS of workers. Consequently, they concluded that workers in these countries like Bahrain are now in hazardous occupations. On a positive move, Bahrain has added a Labour Law Chapter 12 for the private sectors on order (No. 23-1976) in 1979 in order to protect workers from the hazards and risks, regulate and control OHS at workplaces and describe labour inspection adequately (Matooq & Suliman, 2013b; Alaradi, 2010). However, rapid developments in Bahrain economy led MOL and Social Affairs to establish Occupational Safety Section unit to carry out safety awareness programs (Matooq & Suliman, 2013b). In addition, several new orders have been issued since 2000 regarding first aid, medical examination of workers and protecting workers from fire hazard in the workplace.

As the previous sections highlighted the accidents in the O&G industry in general and in Bahrain in specific, main causes of accidents and costs of accidents in the O&G industry, exploratory studies are required increasingly in this industry in general as there is a countless serious occupational accidents yearly. Additionally, attentions should be paid on human error which is one of main causes of accidents in the O&G industry. These attentions should focus on workers as most of the accidents were results of their wrong actions. However, the cultural differences within this risky workplace should be considered also as it plays a key role in increasing these issues especially that foreign workers in the O&G industry in Bahrain have accounted a considerable portion. Nevertheless, the role of top management in this industry should be explicit to fill these gaps and develop solutions and strategies in order to prevent such accidents. Therefore, attention should spotlight on investigating human error accidents in the O&G industry in Bahrain in order to develop a strategy that addresses all that. Accordingly, the next section presents the aim and objectives of this research.

1.4 Research Aim and Objectives

The aim of this research is to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan. This aim will be achieved through several objectives as follows:

1. Define human errors and human factors within the context of accidents in general.

2. Identify the current Occupational Health and Safety legislation, regulations and implementation in the Oil and Gas industry in Bahrain.

3. Critically evaluate the challenges related to human errors specific accidents in the O&G industry in Bahrain.

4. Explore best safety practices from other O&G industries in developed and industrial countries.

5. Refine and validate the recommendations of the industrial safety strategy for the O&G industry in Bahrain.

1.4.1 Research Objectives

The five proposed objectives are highlighted and addressed within different chapters in this thesis. For instance, the first objective is introduced in Chapter 1 and comprehensively discussed in the literature review in Chapter 2. Then, the second objective is addressed in the literature review in Chapters 2 and in the research results and analysis in Chapter 4. The third objective is considered mainly in the research results and analysis in Chapter 4. While the fourth objective is achieved through the literature review in Chapter 2 and in the research results and analysis in Chapter 4. Lastly, the fifth objective is addressed clearly in Chapter 5 utilising from results of literature review in Chapter 2 and of the results of the research analysis in Chapter 4.

Based on the proposed research aim and objectives, research variables have been developed. These variables tend to investigate the current OHS framework in the O&G industry, the human error accidents and its related challenges in the O&G industry in Bahrain through seven constructs which are *Safety regulation, Safety implementation, Top management, Safety training, Safety leadership, Communication and Accidents reporting system*, the adapted best safety practices in the O&G industry and the need for safety strategy in the O&G industry in Bahrain.

1.5 Research Scope and Limitation

This research will be conducted specifically on accidents in the O&G industry in Bahrain that are caused by human errors rather than any other causes. Human error accidents are the focus of this research along with identifying the main challenges that are related to them. As many definitions tried to define human error variously with different purposes, a specific definition of human error is proposed here to suit the current aim and objectives of this research within the O&G industry in Bahrain. Human error in this research is “an unintended failure of achieving the planned outcomes in a form of action, checking, retrieval, transmission, diagnostic and decision errors”. Therefore, this will limit the scope of this research to unintentional actions instead of violations or intentional actions.

The O&G industry has been classified differently by different scholars. The first group has divided it into two main streams which are upstream and downstream (Fanchi & Christiansen, 2016; Robinson & Scott, 2016) while the second group has divided it into upstream, midstream and downstream (Lulic, 2015; NIOSH, 2015; Toews and Alexander, 2015). The O&G in Bahrain is considered popularly as two streams (Oxford Business Group OBG, 2018). This is clear during the standard sale and purchase agreements that are signed in this industry in Bahrain which assume that the upstream refers to exploration, drilling, crude O&G production and transportation to the refinery while the downstream sector includes refining, distribution and storage (Shoker, 2014). Additionally, government in Bahrain incorporated National Oil and Gas Authority (NOGA) to act as a holding company with respect to the various O&G companies in the upstream and downstream (NOGA, 2012). Therefore, this research adapts the classification of the first group as it is more consistent with the O&G industry in Bahrain. Based on that, the upstream involves locating and extracting the crude O&G and the transportation of the crude O&G to the refinery while the downstream involves the processing, refining, storage, distribution and selling of the final product. Apart from that, the focus in this research also is directed particularly to the downstream only.

The downstream of the O&G industry involves many complicated processes and deals with various challenges particularly in distribution, transportation and logistics (Bhardwaj, 2013; STI Group, 2013). HSE (2012) pointed that the highest number of most accidents and dangerous occurrences in 2012/13 in UK was in the maintenance workplaces in the downstream. Bhardwaj (2013) indicated that the downstream has a wider scope and broader and higher challenges than the upstream. He pointed that these challenges appear within different phases like crude oil supply, trading, refining, distributing of products, marketing and selling. For example, the distribution phase of O&G contains an array of places to sell, use, or redistribute using conventional transportation ways via trucks and railway or sea shipping. However, each of the transported product has a nature which requires an extensive network of pipelines and more precise attentions. In addition, all these phases require strongly extensive communications, coordinations and management in order to ensure the efficiency in the various processes and create a favourable point of view among stakeholders.

The downstream of the O&G industry is also viewed as a source of long-term cash (Cheary, 2017; Ernst and Young, 2012). Notably, recent industry developments are proposed in the downstream to expand petrochemical capacity as long-term strategies (Ernst and Young, 2012). These developments focus on large-scale refining and petrochemical integrations. On top of that, the downstream of the O&G industry plays a greater role in the economy as it is an opportunity for a wide range of jobs and employment (Cheary, 2017; STI Group, 2013). Turning the discussion specifically to Bahrain, the downstream contains a cluster of oil refiner and petroleum industries and others. The ongoing growth of this stream is boosting exports and creating more jobs in Bahrain. Data from NOGA's report in 2015 showed that the O&G industry collectively employed 4302 workers of which 787 were employed in the upstream and 3515 were in the downstream (OBG, 2017). In total, the employment in the downstream was about 88%. However, as it was estimated the major investments in the downstream in Bahrain will increase by 2020; therefore, workplaces activities and employment in this stream will increase subsequently (OBG, 2017). Thus, the downstream monopolises the biggest portion of employees in the O&G industry in Bahrain. Based on all these reasons, this research focuses on accidents in the downstream of the O&G industry in Bahrain.

Additionally, there is a wide range of human factors that have been identified previous scholars (HSE, 2016; Mattia, 2013). Some of these factors represent as challenges to different workplaces around the world (Vondráčková, Voštová & Nývlt, 2017; Dumitru & Boşcoianu; 2015; Energy Networks Association, 2013; Gonçalves Filho, São Mateus, Oliveira, Andrade & Muniz, 2012; Shabin & Ramesh Babu, 2012). The current research will focus only on several factors that are safety regulation, safety implementation, top management, safety training, safety leadership, communication and accidents reporting system. Based on these fundamental criteria, this research at the end will develop an action plan to enhance the industrial safety strategy for the O&G industry in Bahrain that will help in reducing the current rate of human attributed accidents. However, it is important to mention that reviewing OHS framework in this industry in Bahrain and best safety practices in the O&G industry in general will play a key role in achieving the research aim.

After explaining the scope of the research, it is important to describe the adopted research methodology within this research. The next section provides that.

1.6 Research Methodology

Research methodology prescribes the systematic plan or approach that is adapted in a certain research in order to reach appropriately the proposed aim, objectives and questions. The adopted research methodology in this study is the 'research onion' model that was proposed by Saunders, Lewis & Thornhill (2012). Within this model, the researcher adapts the interpretivist stance as the core research philosophy due to two main reasons. The first one is because it is considered as one of social sciences research. The second is because it focuses on getting the perceptions, opinions, beliefs and attitudes of workers who involve in the managerial and operational levels in the O&G industry in Bahrain regarding human error accidents. Hussey and Hussey (1997) and Collis and Hussey (2009) have supported that. Additionally, this research follows the abductive research approach and adapts case study as a research strategy that is based on multiple case studies. The three case studies were refining, distributing and storage units.

The secondary data was collected from existing published relevant materials like books, academic journals and professional sources whilst the primary data collection were semi-structured interviews for the managerial level and questionnaire surveys for the operational level. In achieving its aim and objectives, this research implements the first model of linking the qualitative and quantitative method proposed by Miles & Huberman (1994). In this model, firstly, the researcher conducted the qualitative data and the quantitative data methods simultaneously by interviewing respondents and distributing the questionnaire surveys. Then, findings from these channels are integrated together to build the conclusion. 12 Semi-structured interviews were conducted for the managerial level of these units through the purposive sampling. While in total 226 questionnaires (75 for each unit and one for the representative who is responsible for administrating these three units) were distributed through simple random sampling. Out of which 163 (57 from refining unit, 52 from distributing unit and 54 from the storage unit) were valid and completed. Content analysis is conducted for the qualitative analysis, while descriptive and inferential statistics are deployed for the quantitative analysis. More detail about the adapted research methodology is presented in Chapter 3. The next section illustrates the contribution to knowledge.

1.7 Contribution to Knowledge

In general, there is a lack in studies and documents that highlight occupational accidents mainly in the energy sector (Rahmani, Khadem, Madreseh, Aghaei, Raei & Karchani, 2013; Sanmiquel, Freijo, Edo & Rossell, 2010). Nevertheless, few studies have explored human error accidents in the O&G industry (DNV.GL, 2016; Dräger, 2015; Taylor, 2013). As this study highlights a specific phenomenon in the O&G industry which is human error accidents with its main challenges particularly in the downstream of this industry in Bahrain from the points of view of the managerial and operational levels, it contributes to theory and practice in several manners. The next sub-sections will discusses that.

1.7.1 Practical Contributions

Practical knowledge is mainly useful for having a deep insight and detailed understanding of the research problem and areas. This research might be an interest of Bahraini government, the O&G industry, OHS regulators, partnerships, practitioners, managers, policy makers and other parties that have an influence at any level over the O&G industry in Bahrain. Additionally, it provides valuable information to improve, redesign and restructure the current OHS framework and training and professional programmes that are used in this industry. Further, using the information of this research particularly regarding the OHS framework would be effective during the strategic planning phase in this industry. This study contributes practically through the development of a useful industrial safety strategy as a solution for this industry to reach it goals and objectives adequately by focusing on reducing human errors that lead to accidents and undesirable additional costs. This means that this study also can be used as a tool for evaluating some challenges related to human error accidents faced by the O&G industry in Bahrain.

The results of this research can lead to changes in methods or practices in the workplace and in the overall O&G industry. In other words, this research acts as a platform for change for the O&G

industry. This change is represented by gaining many fruitful benefits. First, awareness regarding safety issues will increase and many useful implementations will be proposed. Besides, this industry will focus more on adapting the appropriate safety standards and regulations that comply with international safety standards. This will add positive values to safety culture in this industry. For example, communication between stakeholders will record a considerable development especially between managerial level and operational level in order to work collaboratively as a team. However, effective modifications will be inherited to accidents reporting systems in order to increase the reliability and accuracy of accident data. In addition, the developing an action plan will assist the O&G industry in Bahrain in increasing safety quality and productivity and reducing the cost of accidents.

1.7.2 Theoretical Contributions

Based on the results of the literature review, there was a lack of resources regarding human error and the role of human error accident in the O&G industry as applied to Bahrain. This is a surprising gap in the literature especially in Petroleum countries like Bahrain given the above setting of this industry. Therefore, this study is considered as the first of its kind in this industry. It is expected to contribute to the existing body of knowledge about this phenomena in order to understand human error accidents in the O&G industry, provide insight for practitioners and open doors for other safety research in this industry. As well as, this study is considered as the first of its kind in term of asking the managerial and operational levels in the O&G industry about their concerns and opinions. This gives both professionals and academics a unique understanding and spotlights on this latent phenomenon and its related issues. This study provides data and accessible information locally and regionally to other GCC countries. Moreover, by having clearly the critical challenges in this study, Bahraini government and the O&G industry will use these results to take actions that improve the overall OHS legislations and regulations for this industry and increase the OHS performance.

On top of that, Bahrain announced recently in 2018 the discovery of the largest oil discovery in Bahrain which contains 80 billion barrels of oil in place and 13 trillion cubic feet of natural gas. Thus, it is important to conduct empirical studies in the context of the O&G industry of Bahrain in order to contribute to a better understanding of the risks, challenges and barriers in the workplace and in order to know the current requirements of the workplace in term of OHS regulations and standards, techniques, technologies and tools. This means that more recent investigations and studies in this industry in Bahrain is utmost important currently and has been of interest to different actors in this industry. Accordingly, this research is one of these investigations. It focuses particularly on the downstream of the O&G industry in Bahrain as it is the focus area of the recent governmental projects in this industry. As well as, this study contributes to theory by expanding the understanding regarding human error accidents in the O&G industry in Bahrain. Moreover, it will provide a broader insights regarding the current OHS framework in Bahrain.

1.8 Thesis Structure

The organisation of this is outlined in the following points:

- **Chapter 1: Introduction.** The first chapter presents an introduction to the overall thesis by covering research background, research justification, aim and objectives, scope and limitation, a summary of the adapted research methodology, and practical and theoretical contribution of the research to knowledge.

- **Chapter 2: Literature review.** The second chapter presents a literature review relating to the study by presenting the following phenomena OHS, accidents, human error and human factors. To explore these and other phenomena in this chapter, this research takes advantage form several available literatures (books, journal articles and reports). In addition, this chapter discusses some best safety practices in the O&G industry. All these topics were covered to clearly understand the role of human error accidents in the O&G industry. After that, an extensive discussion on this industry in Bahrain is included by focusing on the challenges of this industry in Bahrain. Finally, the need for an effective industrial safety strategy for the O&G industry in Bahrain is illustrated.

- **Chapter 3: Methodology.** The third chapter illustrates the design of the adapted research methodology by explaining the philosophical assumption of the research. Additionally, it demonstrates the research philosophy, approach, strategy and the methodology that are used to reach the current aim and objectives. Then, it presents how validity and reliability are accomplished in this research.

- **Chapter 4: Results and Analysis.** The fourth chapter presents the results of analysing the collected data during the data collection phase through the qualitative and quantitative methods.

- **Chapter 5: Discussion.** The fifth chapter provides the findings from the empirical analysis by describing the final refined industrial safety strategy to the O&G industry in Bahrain. First, it expresses the main empirical findings and linkage followed by the essence of an industrial safety strategy. Then, a comprehensive discussion on the overview of the proposed strategy is provided by looking in depth in its vision, mission, outcomes, outcomes, users, performance indicators and results and key action areas. The refining process to this proposed strategy and the main amendments to it are highlighted and explained. Lastly, the final conceptual view of the industrial safety strategy is presented.

- **Chapter 6: Conclusion.** The last chapter draws a conclusion for the proposed aim and objectives in the current research. It provides also a synthesis of the new results. The limitations and practical and theoretical significance of this research are presented. Finally, recommendations for future research topics of the thesis and final note are also discussed.

1.9 Chapter Summary

The O&G industry plays a key role in the global economy and particularly in the Middle East countries. For instance, this industry in Bahrain is the backbone of the economy. The O&G industry involves several activities starting from exploring and drilling to distributing and marketing. Currently, this industry has different challenges like the fluctuation of oil price, the increasing in O&G demand, the trend of reducing costs, the intensive dependency on capital and technology and the consequences of globalisation. Based on these circumstances, the O&G

industry will increase workplace activities and this will result in increasing the probability occupational accidents. However, the fatality rates for workers in the O&G industry have historically been higher than the rate of other workplaces. Additionally, the accidents rate in Bahrain in the manufacturing sector including the O&G industry is in an increasing trend. Nevertheless, the cost of these accidents is considerable. Based on different literatures, many causes were behind this high rate in the O&G industry. Ineffective safety management programs, inexperienced workers, poor training programmes, inadequate maintenance plans, poor supervision, ineffective hazard identification measures, inadequate auditing strategies and human error are examples of these causes. Several authors like Mattia (2013), Torp (2015) and Bhavsar et al. (2015) confirmed that human error was the dominant contributor of over 80% of all the O&G industry accidents. In Bahrain, Freije (2015), Naser (2011), De Mora et al. (2010), De Mora et al. (2004), Madany et al. (1998) and Madany et al. (1994) have remarked that human errors were the primary causes of accidents as well in operational and maintenance workplaces in the coastal areas of the O&G industry. Based on all these conditions, the O&G industry in Bahrain should focus on investigating human error accidents in this industry in Bahrain. Accordingly, this research aims to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan. The next chapter presents the literature review of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A literature review is a core component of a thesis. It provides an overview of the field of inquiry by covering the previously discussed related topics, the main contributors in this field, the dominant theories and hypotheses, the relevant questions, and the appropriate methodology or methods for the continued research. The literature review here begins with describing the workplace background. Then, this thesis presents OHS terminology by covering its definition, benefits and leaders of OHS bodies. Further, it discusses occupational accidents. After explaining all these terminologies, it presents human error and human factors. Then, it turns the discussion to best practices in the O&G industry. This discussion is followed by a detailed deliberation on Bahrain, its O&G industry and the key challenges to this industry. Further, the main issues regarding having a safety strategy in general and in the O&G industry in Bahrain are provided. Finally, the last section summarised the whole chapter.

2.2 Workplace Safety

Various social, regulatory, political, technological, sociological health and economic modifications and alterations have emerged in the current context which consequently affect most workplaces by introducing multiple restructuring, redesigning and repositioning of OHS works (Ellwood, Reynolds & Duckworth, 2014; WBG, 2011; Alli, 2008). These changes are like redesigning health and safety procedures, psychosocial risk management, role of worker representation, and OHS of workers.

On the other hand, the worldwide globalisation of economies and its consequences are strategic forces for changes in today's working environment and subsequently in the scope of OHS (Alli, 2008). According to Baylis, Smith and Owens (2014), globalisation is the most crucial influence in today market as it requires to interconnect workers from different backgrounds in one single location utilising hardly from complex technologies. As a result of these changes, most workplaces are facing a wide range of various new norms and values that are shared amongst all workers

(Kouabenan, 2009), in addition to new varieties and designs of techniques, hazards, exposures, risks and knowledge that are produced and emerged (WBG, 2011; Alli, 2008). It is universally accepted, based on the Preamble to the Constitution of ILO, that protecting all workers from work-related illness, sickness and injury is an essential concern (ILO, 2017). Therefore, safety, industrial safety, risk, perceptions of risk, beliefs, safety culture and causes of accidents should be managed effectively in order to control risks and design preventive measures in workplaces to protect workers (Kouabenan, 2009).

Risk is a condition where something of human value has been put at stake and where the outcome is potentially unpredictable and uncontrollable (Rosa, 2003). While hazard is a dangerous circumstance or event that threatens or has the potential that leads to damage to property or environment and injury to life (Khan, Vasilescu & Khan, 2008). In other words, a hazard is a condition that has the potential to cause harm. Awodele, Popoola, Ogbudu, Akinyede, Coker & Akintonwa (2014) and WBG (2011) found that these hazards could lead to chemicals, physical, biological and ergonomic risks. Fire, explosions, leakage, spills, and exposure to vapors, gases, mists, fumes and dust are common chemical risks. In fact, these chemical substances are widely used in industrial sector to bring immense benefits; however, it had large negative impacts on the OHS of workers and environment (Awodele et al., 2014). Slips, falls, trips, noise, and tremor are examples of physical risks. Disclosure to viruses, bacteria, biogenic toxins, and allergens are a biological risk. Lastly, muscular-skeletal problems that result from manual handling activities such as lifting and carrying, or from being in one place for long periods such as sitting at desks and working with computers, are common ergonomic risks.

Based on that, safety during the industrial world history was the building block of any industrial safety policy which describes individual attitudes, corporate policies and regulatory practices. This was reflected in numbers of believes or myths that had been shared like ‘safety first’, ‘safety comes first’ and ‘most accidents are caused by human error’ (Besnard & Hollnagel, 2012). Logically, safety is the absence of undesirable events that involves an unplanned and unacceptable loss (Leveson, 2004). Many earlier authors prescribed it as a freedom from hazard and unacceptable risks. Further, many professionals linked safety and risk together and they agreed that safety is the antonym of risk and safe criterion can be determined by acceptable risk level (Ayyub, 2014; Aven, 2014; Manuele, 2013).

However, today more than ever, many industries have started to respond to the concern of identifying, assessing, and controlling different risks in order to ensure an effective level of safety in the workplace utilising from highly trained staff and rational workers and precisely selecting effective indicators and methods (Besnard & Hollnagel, 2012; Kouabenan, 2009). Thus, having a clear understanding on OHS and accidents is important at this stage. The next section explains OHS clearly.

2.3 Occupational Health and Safety Definition

OHS is defined as a science that anticipates, identifies, evaluates and controls hazards and risk in a workplace which could harm the health and well-being of workers, surrounding communities and surrounding environment as a whole (Alli, 2008). WBG (2011) explained that OHS concerns on providing and maintaining the highest level of mental, physical and social well-being of all workers regardless of their occupations, avoiding departures from workers' well-being and health, protecting workers from any potential risk type in the workplace and building and ensuring adequate and safe working conditions that match the physiological and psychological capabilities of workers. Therefore, OHS touches several phenomena related to scientific aspects like economics, law, medicine, physics, chemistry, ergonomics, technology and other areas related to industry nature and activities. However, these aspects contain an array of significant principles underpin the field of OHS that all tend to achieve one vital objective which is building a safe and healthy environment (Ellwood et al., 2014).

Furthermore, Ellwood et al. (2014) argued that although providing and managing OHS of a workplace depend on the type of the performed operations and functions and the types of the current risks, recent legislations of OHS usually demand to start with a risk assessment before any activity in order to ensure that risks be reduced as low as reasonably practicable. Guidotti (2011) described it as a complex and dynamic process that have long-term objectives. This system requires a variety of organisations, skills, knowledge and logical capabilities in order to manage and implement effective protection to both workers and the environment.

In this regard, building a safe and healthy environment requires a successful OHS management system that covers most critical aspects of any workplace. These aspects are appraised in the next section.

2.3.1 Occupational Health and Safety Management System (OHSMS)

OHS management system deals with protecting workers and building a strong safety culture between employers and employees by adapting many OHS regulations, standards, policies and practices advocated by proponents of quality management, environmental protection, and business excellence. A high safety performance ensures becoming a world-class competitor during this rapid globalisation of trade (Unnikrishnan et al., 2015). As the health and safety of workers are directly associated with the quality and productivity of a workplace, many workplaces have established OHS management systems that commensurate with their risks (Awodele et al., 2014). IOSH (2015) considered OHSMS as a principle tool to address the multitude of risks in different workplaces. According to Chauhan (2013), Pheng & Pong (2003) and De Oliveira Matias and Coelho (2002), OHS management system is characterised by several characteristics as the followings:

- It should develop OHS management systems that eliminate and diminish risks for all.
- It should build, maintain, and frequently update OHS management systems.
- It should ensure and demonstrate clearly its compliance with the current internal and external OHS framework requirements.
- It should be accredited by external organisation.
- It should provide self-determination and declaration of conformance within conditions.

Additionally, WBG (2011) agreed that the success of any OHS management system depends on three factors as the following:

1. Two-way communication with the employees is vital to this success along with extensive collaboration and cooperation activities.

2. Documentation and reporting of all activities and processes of health and safety programme is important.

3. Regular inspection and auditing.

Based on these points, OHS management system should provide a worker with different methods of communications to interconnect with all other workers at all levels. This can be achieved by utilising from the recent advancement in technologies. Additionally, another critical point to the success of this system is the proper documentation and reporting for matters in the workplace like safety policy, training courses, OHS meetings, information that have been disseminated to workers and medical examinations made. However, other significant records such as those legally required for compensation, insurance, auditing and governmental issues must be maintained during the existence of the actual need. On top of that, these records may be used as references for enhancing and improving the current operations. Records of accidents and property losses may be used to prevent recurrence of these undesirable events by developing new procedures. Finally, the last point that affects the success of OHS management system is the regular inspection and auditing in order to identify the areas that have an acceptable level of improvement, the areas that require more improvement, the nature and type of the required improvement and changes.

Based on the importance of a successful OHSMS to reduce occupational accidents and ensure the protection of workers, the practical procedures and outlines to design, formulate, build, operate, and maintain an effective one should be highlighted. IOSH (2015) developed a formal OHS management system that is composed of ten components which are policy, organising, workers' representatives, communicating methods, consulting, implementing and operating, measuring performance, corrective and preventive actions, management review and continual improvement.

1. Policy is a mission statement to demonstrate the commitment and vision of workplaces and to facilitate management's control and accountability. Planning is the process of building a plan for identifying, assessing and reducing risk, developing the emergency plan and identifying legal, regulations and standards that apply. Additionally, the long-term OHS objectives, plan, policies, targets and actions should be set out.

2. Organising concerns with defing the structure of the organisation, allocating of OSH roles and responsibilities and determining the required training, competence and consultation.

3. Workers' representatives are crucial element that positively contribute to the response of workplace to risk and opportunities.

4. Communicating methods between managers and workers should be strong to share useful materials starting from information and work procedures to the description of the system itself.

5. Consulting is important to tap information into the fund of expertise and knowledge of clients, suppliers and other stakeholders in order to shape the risk management programme.

6. Implementing and operating translate practically all the predefined and designed plan, objective, targets and other activities like risk assessment and audit.

7. Measuring performance of reactive data, which are records of accidents and other harmful events, and active data, which are results of frequent inspections, OHS, committee functions, risk assessments, training. Formal audits should evaluate the overall performance of the system.

8. Corrective and preventive actions. One of the main purposes of this OHS management system is to identifying opportunities for that assists in reducing and preventing accidents by investigating previous accidents, failures, harm and work-related bad events. A wide range of techniques is adapted to identify the weaknesses and to explore new methods to prevent these events or failures.

9. Management review is the top-level evaluation to examine and determine the effectiveness of OHS management system by focusing on the design and resourcing objectives. This ensures that the compliance with the relevant legal and other requirements is regularly tested.

10. Continual improvement (heart of the system) is a continual essential commitment to control and manage OHS risks and issues proactively in order to reduce the possibility of accidents effectively and to achieve the desired aims and objectives efficiently.

On the other hand, HSA (2006) developed another OHSMS that is composed of core components, which are policy and commitment, planning, implementation and operation, measuring performance and auditing and reviewing performance.

1. Policy and commitment: The organisation should develop an OHS policy to set out a clear direction for the organisation to follow. This policy is a way of demonstrating the current and future improvements in the organisation. All are responsible to be committed to this police. Cost-effective methods to preserving and improving human and physical resources strongly will decrease costs, losses and liabilities.

2. Planning: The organisation should build a plan to practically perform its OHS policy. This plan should systemically structure and manage the delivery of the policy. OHS objectives and targets should be outlined for all stakeholders.

3. Implementation and operation: Once the OHS policy and plan have been developed, an effective implementation is required. To achieve an effective implementation, the organisation should set up the required capabilities and support mechanisms necessary to reach its OHS policy, objectives and targets. Appropriate involvement and participation, adequate empowering and motivation for all workers to fulfil their work safely and to protect their long-term health and effective communication methods and strong promotion for competency are critical to this support. Further, risk assessment methods and techniques should be adapted to control priorities and develop objectives for avoiding hazards and decreasing risks. The selection and designing of workplaces, equipment and procedures play a key role in reducing risks. Likewise, vital factors and actions that promote a positive safety culture should be recognised. Visible and active role of safety leadership can assist in fostering this culture.

4. Measuring performance: The OHS performance of an organisation should be measured, observed and evaluated against the agreed regulations and standards. There are active and reactive monitoring. An active self-monitoring shows the effectiveness of OHS management system by emphasising on plant, material, equipment, people, systems, procedures, behaviour and performance. A reactive monitoring starts when the control failed to identify the reasons behind this failed. This will be achieved by investigating the accidents or bad events that resulted harm or loss. However, both active and reactive monitoring aim to indicate the immediate causes of poor level of performance and to determine any primary causes and consequences for the overall structure and components of OHS management system.

5. Auditing and reviewing performance: A continuous systematic reviewing and improving for OHS management system is utmost important. This will permit the organisation to learn from relevant experience and pervious lessons learnt. The systematic review involves monitoring and auditing results. While a continuous improvement of OHS management system involves OHS policies, plans, systems and risk measures and controls. There are two types of performance assessment which are internal types by referencing to the key performance indicators and external type by referencing to the performance of other competitors and best practice in the same industry. Results from auditing and reviewing performance should be kept for further future purposes. HSA (2006) outlined the structure of OHS management system as presented in Figure 2.1.

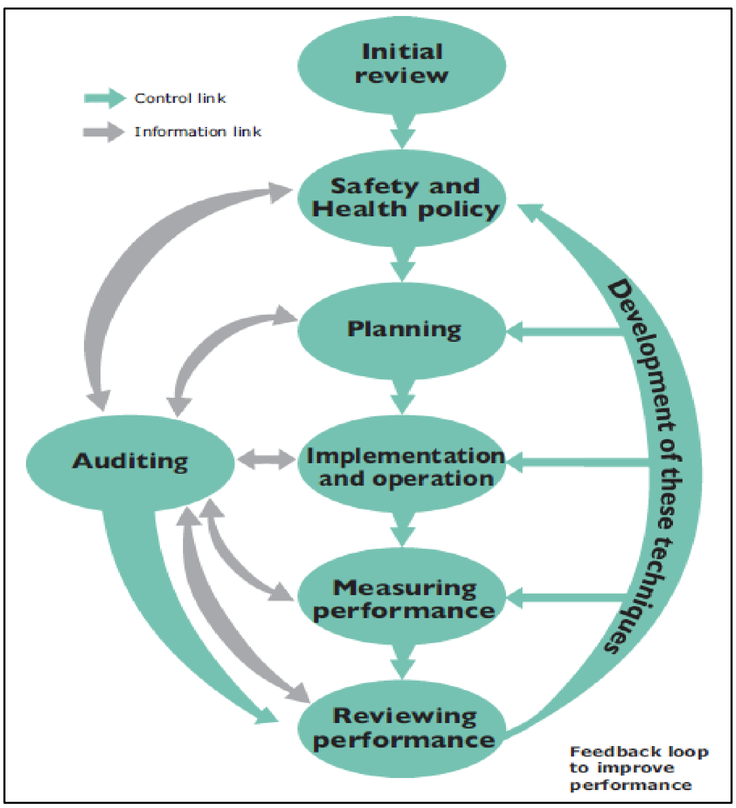

Figure 2.1: The structure of OHS management system, (Source: HAS, 2006)

Based reviewing these two approaches for OHSMS, most of factors and OHS principles covered by these two approaches are the same regardless of the number of components. Both approaches aim to provide a healthier and safer workplace and to reduce the probability of accidents within a workplace. Having a clear and consistent OHS statement or policy is the starting point for this system. Then, setting out the required objectives, regulations, rules, and targets that are aligned with this statement, allocating resources and assigning responsibilities for managers, safety leaderships, workers and all stakeholders are the second step. This step is followed by a practical implementation for this system. As the implementation and operation started, there should be a hazard identification, risk assessment and regular measuring, auditing and inspecting for the outputs and results. Comparing the desired outcomes with the actual results and building corrective actions are important. Finally, a continuous improvement for this system is required based on the dynamic nature of workplaces and other external factors like market requirement, regulatory requirement and advanced technologies. The next section discusses the benefits of OHSMS.

2.3.2 Benefits of OHS Management System

Díaz-de-Mera-Sanchez, Gónzalez-Gaya, Morales and Rosales (2015) and WBG (2011) asserted that a successful management of OHSMS invariably increases the performance of staff and the availability of work and assists in hiring and retaining fundamental skills and expertise. They also asserted that this system inhibits the potential disability discrimination, decreases the total cost of workers compensation and medical insurance, reduces the faulty products and increases the level of morale, the usage of human resources and the relations between labour and management. In other words, fostering a safe conditions and environment means that an individual is more likely to be more productive and stimulated, has better job satisfaction and contributes positively on the quality of products and services. Thus, OHSMS system will assure the required setting to conduct the daily functions, operations and tasks safely and correctly and will enhance the overall quality of society and individuals' life. According to García-Herrero, Mariscal, García-Rodríguez & Ritzel (2012), this system tends to create capabilities, conditions, and habits that assist the workers to fulfil their tasks efficiently and in a way that prevents any possibility for events that cause harm.

Aligning with this issue, Alli (2008) noted that the performance of OHS management system depends on the type of the country, type of the economic sector and size of workplaces. He stated that country differences mean that workplace accidents vary significantly between developed and developing countries, as an example the probability of fatality rate in a factory in Pakistan is eight times more than a factory in France. Whereas he indicated that economic sector differences mean that occupational accidents vary significantly between economic sectors as the highest rates occur in O&G, mining and construction industries. Lastly, he stated that different of size of workplaces means that small workplaces have worst statistics in safety than other larger workplaces.

Based on all that, an adequate implementation of effective OHS management system in workplaces assists in exhibiting many powerful strengths related to staff performance, learning, communication and relationships, job satisfaction, OHS performance, morale and resource management in addition to inhibiting several weaknesses related to disability discrimination and different costs. However, several influences may affect the results of this system like type of the country, type of the economic sector and size of workplaces. In general, OHS principles are universal but the required actions may differ based on the size of the organisation, level and nature of risk and hazards, the physical characteristics of the organisation, final products or services, and the adequacy of the current circumstances. As a safe workplace is translated by reciprocal and interactive relationships between the work environment and the workers in term of promoting healthy well-being, job satisfaction, and ultimately, higher productivity, several worldwide bodies have been established to address this issue and to respond to the profound changes and development that have been accounted globally in different industries. Some examples are presented in the next section.

2.3.3 Leading OHS Bodies

In general, the pattern of the profound changes and development that mentioned previously is shaped through the development of OHS. Therefore, there are several leading bodies in Asia and the Pacific that are responsible for promoting OHS (Park & Khai, 2015). These bodies are responsible for facilitating the new paradigm for OHS of workers that has emerged and increasing legislations, conventions, standards and codes of practice that concern on protecting the health and safety of all workers. These legislations, conventions, standards and codes of practice are produced consistently for the national authorities and services, employers, workers and public and private enterprises (Alli, 2008). These bodies are like the Korea Occupational Safety and Health Agency (KOSHA) and ILO.

The Korea Occupational and Health Agency (KOSHA) was created in 1987 aiming at building a safe and health workplace for all workers through avoiding accidents, enhancing the working conditions, reducing and eliminating diseases and encouraging enterprises to launch accident prevention activities (KOSHA, 2016). In addition, this official health and safety agency of the Republic of Korea is needed as industries become more complex and diverse in order to reduce occupational accidents that weaken the competitiveness of businesses and decelerate economies (KOSHA, 2016). While the ILO was established in 1919 aiming at preventing occupational accidents and work-related diseases since its creation and continues to be so today.

Indeed, Alli (2008) found that around 80% of all ILO standards and instruments are closely related to OHS issues and this breadth of penetration indicates clearly the importance of OHS as a core element of ILO activities. ILO promotes OHS in a mean of international labour standards, codes of practice, the provision of technical consultation and sharing useful information. ILO explores, updates and maintains OHS areas continuously. Further, ILO develops the International labour standards that embody conventions and recommendations about labour and social problems like employment, the informal economy, labour statistics, labour inspection and maritime safety.

However, Korean Ministry of Employment and Labor and the ILO in 2003 signed a memorandum of understanding that focuses on developing some countries in Asia cooperatively through implementing a new programme called the ILO/Korea Partnership Programme (ILO, 2010). This programme covers three areas of the regional priorities which are competitiveness, productivity, and jobs; governance of labour market and social protection; and management of labour migration (ILO, 2010). The second area consists of OHS component and OHS activities such as training programmes, workshops and improvement of OHS manuals. In fact, the OHS activities mainly concern on improving OHS and working conditions in workplaces within the region (Park & Khai, 2015).

At this stage, it is important to have a quick review on occupational accidents. The next section will provide that.

2.4 Occupational Accidents and Causes

Through the last few decades, there is an increase in occupational accidents figures around the world (Hämäläinen, Takala & Kiat, 2017). For instance, around 1.6 million industrial accidents occur in the U.S. yearly ranging from minor accidents to deaths (Zakaria, Mansor and Abdullah, 2012). However, this increasing trend is nowadays an alarming sound during the pressure of globalisation and stiff competitions to deflect attentions to OHS considerations (Alli, 2008). Many researchers asserted that risks and accidents should be seriously addressed and promptly monitored (Díaz-de-Mera-Sanchez et al., 2015; Zakaria et al., 2012; WBG, 2011). Additionally, defining occupational accident and identfying the causes of these accidents are the main prerequisites for this deflection in order to prevent these accidents and formulate accurate organisational policies for improving safety performance (Unnikrishnan et al., 2015; Alli, 2008).

In fact, disregard to the number of studies on the subject of occupational accident and OHS management, there is no universal definition among a variety of occupational accidents definitions (Niza, Silva & Lima, 2008; Condit, Dubriwny, Lynch & Parrott, 2004; ILO, 2002). Niza et al. (2008) indicated that there is a variety of occupational accident definitions in use, depending on the authors' scientific domain and nationality. This variety is also affected by the geographical, economic, and the political situation of the countries (Guha-Sapir, Vos, Below & Ponserre, 2012; Niza et al., 2008; Eshghi & Larson, 2008).

Several occupational accident definitions stated it as an undesired and unplanned event that leads to deaths, personal injuries, damage or loss to property, plant, materials or the environment and/or a loss of business opportunity (HSE, 2013; Zakaria et al., 2012; Saldaña, Herrero, del Campo & Ritzel, 2003). Unnikrishnan et al. (2015) explained it as a matter that is associated not only with these high numbers of accidents but also with numbers of permanent disabilities, deaths, economic damages and losses. While in comparison, Zakaria et al. (2012) explained it as a matter that is associated not only with a devastated impact but also with a major impact on daily operations and production of a workplace.

According to HSE (2013), although an accident is defined commonly as an undesirable or unfortunate event that occurs unintentionally and usually leads to harm, injury, damage, it can be defined by law as an event that results in injury and the injured person have the right to seek for compensation or indemnity legally. Collectively, all these definitions emphasised on addressing three aspects. First, it is an unplanned and unexpected event or happening. Second, it is undesirable event. Third, it is an event that has a significant setback to the development of a workplace like injury to a person, interruption to work activities and damage to property. Various causes of accidents were identified from bulk of literatures. These causes are discussed in the next sub-section.

2.4.1 Causes of Occupational Accidents

Bulk of literatures have paid attention to investigate the causes of accidents in workplaces (Zakaria et al., 2012; Gibb, Haslam, Gyi, Hide & Duff, 2006; Saurin & de Macedo Guimarães, 2008). Identifying the causes of accidents is a step to structure the setting of accident situation and it is a fundamental requirement for preventive action (Butchart, Kruger & Lekoba, 2000; Kouabenan, 2009). Form the traditional point of view, occupational accidents are caused by individual human failures as well as technological failures (Reason, 1990). Additionally, demographic and lifestyle factors, working conditions and health factors contribute to numbers of accidents (Chipman, 1995; Frone, 1998; Wells & Macdonald, 1999; Leistikow, Martin, Jacobs, Rocke, & Noderer, 2000). Age, gender and smoking are examples of demographic and lifestyle factors (Leistikow et al., 2000). Level of noise, pressure, risk and heat, nature of machinery, workplace and ergonomic factors, and competence are examples of working conditions (Bjerkan, 2010; Fischer, Martins, Oliveira, Teixeira, Latorre, & Cooper, 2003). Any perceived general health symptom or ill symptoms like musculoskeletal pains, allergic reactions and impaired hearing are examples of health factors (Bjerkan, 2010). On the other hand, researchers through the four last decades have increasingly recognised that occupational accidents occurred in number of industries due to a dynamic interaction between social and physical factors in the environments, characteristics of the workers and characteristics of the organisation and technical forces (Bjerkan, 2010).

Bell & Healey (2006) indicated that by reviewing a number of literatures on the causes of major hazard accidents and the appropriate control measures and behaviours that can reduce the probability of these accidents, human error was a main cause of major accidents in hazards industries like nuclear industries, O&G industries and chemical industries. They indicated also that poor role of management, pressure to demand targets, inadequate safety management systems, failure to learn from previous lessons, communication, insufficient reporting systems, complacency, violations/ non-compliance behaviour, poor training, lack of competency, fatigue, insufficient procedures, new changes in the working conditions and inadequate maintenance are the main contributors to occupational accidents in these risky industries. On contrary, Lubega, Kiggundu, & Tindiwensi (2000) found that lack of awareness regarding the proposed safety regulations, poor enforcement of safety regulation, lack of safety consideration among workers, lack of employee competency, non-vibrant professionalism, failure of machinery, stress and chemical impairment are main courses of occupational accidents in construction industry. Another research on occupational accidents in the construction industry revealed that occupational accidents is a collection of several failures in the factors including; demographics and organisational factors, nature of occurred accidents, factors associated with the working conditions and equipment, unsafe acts/action and unsafe settings such as poor housekeeping, lack of safety training, poor risk controls and measures, and factor related to the location specification (Ahmad, Iraj, Abbas & Mahdi, 2016).

In general, the main causes of accidents are poor role of top management (HSE, 2012; Zakaria et al., 2012; Lu & Yang, 2010), poor role of safety leadership (Westhuyzen, 2015; Unnikrishnan et al., 2015), poor safety culture (Unnikrishnan et al., 2015; Boughaba, Hassane & Roukia, 2014), poor design of workplace (Zakaria et al., 2012; Harley and Cheyne, 2005), defective or dangerous machinery (Zakaria et al., 2012; Payne, 2011), ineffective reporting and recording system (DNV.GL, 2016; Gordon, Flin and Mearns, 2005; Anderson, 2005), improper usage of the adapted technology (Minatsevich, Sharonov & Borisov, 2015; Unnikrishnan et al., 2015), high stress (Galizzi & Tempesti, 2015; Abbe, Harvey, Ikuma & Aghazadeh, 2011), low level of education (Baron, Steege, Hughes and Beard, 2014; Salminen, 2011), improper training (Unnikrishnan et al., 2015; Zakaria et al., 2012; Male, 2003) and lack of multi-professional approach (Harrison & Dawson, 2016; Baron et al., 2014). These causes are summarised in Figure 2.2. The next section illustrates human error as a main cause of accidents.

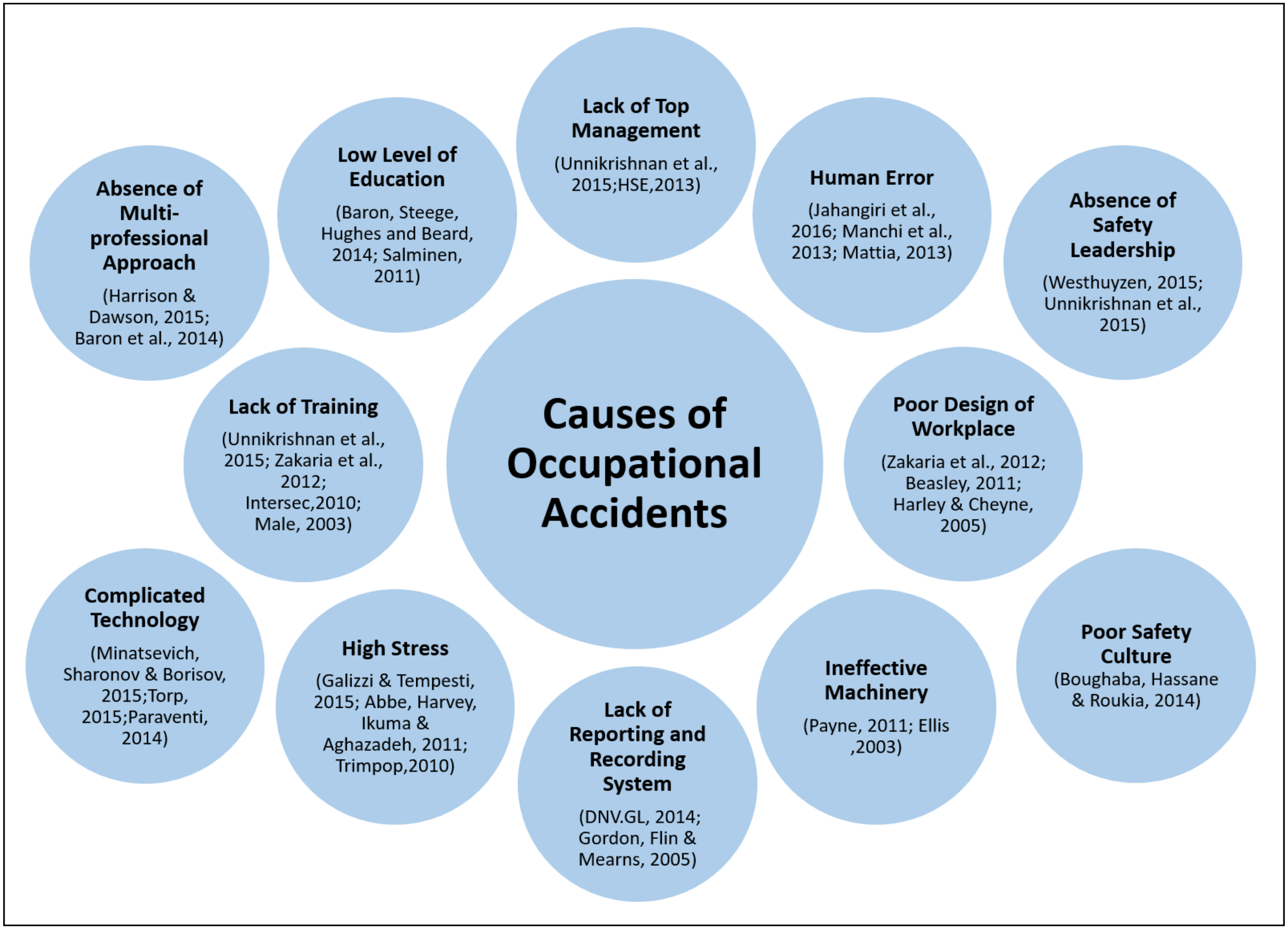

Figure 2.2: Causes of Occupational Accidents

2.5 Human Error Accidents

Over the last 15 years, many researches in safety and human error aspects (Jahangiri et al., 2016; Manchi et al., 2013; Mattia, 2013) have confirmed that a substantial proportion of accidents were resulted from human error. Mattia (2013) and Patel et al. (2012) found that human error was and still is a concern of different researches and books since the Domino Theory of Heinrich (1931). This theory indicated that human errors contribute to 88% of workplace accidents and it blamed workers regarding the 'error' they made due to some behavioural issues or insufficient perception of risk (Patel et al., 2012). Human error is an improper decision or behaviour of a worker which may has a negative impact on the effectiveness of safety performance system (Jahangiri et al., 2016). Obviously, various errors can be identified everywhere because of human nature (Manchi et al., 2013). Mattia (2013) interpreted human error as a natural consequence that was resulted from a break between human capacities and the demands of processes and procedures. Moreover, Mattia (2013) explained that human error is a result of lack of situation awareness or understanding. He stated situation awareness as the perception of components in the process environment, the understanding of the meaning of these components and the projection of their situation in the future.

However, earlier researches also had expressed human errors. For example, Zhu and Xiao-ping (2009) found from the perspective of human mind that human errors happen due to the artificial mistakes, whether intentional or unintentional. As well as, Zeng et al. (2008) claimed that human errors that potentially cause an accident can be referred as unsafe acts that depart from hazard control or job procedures to which the person has been trained or informed and in turn these acts lead to unnecessary exposure of a person to hazards. From another perspective, Stanton and Wilson (2004) stated human error as a characteristic of an individual or a personality trait. While Anderson (2005) pointed that human error reflects the ‘fault’ of someone at the sharp end which may be the last person who touched the equipment.

Nevertheless, Reason (1990) found that human failure is divided into two main categories which are human error and violation. Human error is by definition, an unintentional action or decision whereas violation is a deliberated intention to do the wrong thing or to depart from safe operating procedures, recommended practices, rules, standards or any noncompliant acts but not the bad consequences. Simply, human error is the failure of planned actions to reach the desired aim (Reason, 1990). Further, human error is divided into three main categories such slip, lapse and mistake as shown in Figure 2.3.

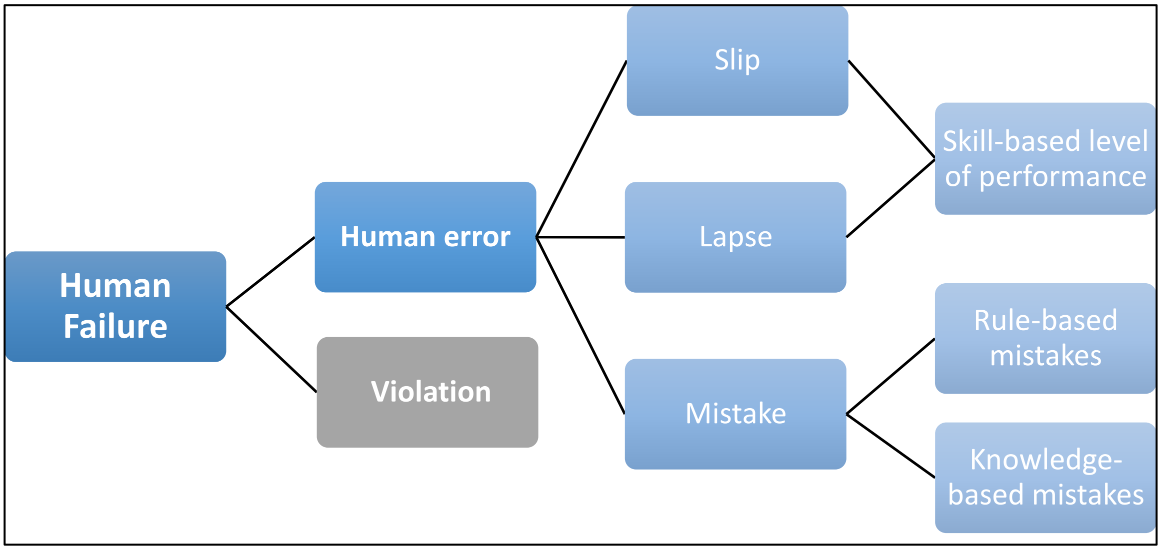

Figure 2.3: Human Failure, (Source: Reason, 1990)

Slip and lapse are considered as failures in the execution time of routine and well-practiced tasks in a familiar environment (Embrey, 2005). Within these two categories, the planned action does not go as planned or properly because something happened and prevented that. Slips occur when actions were not carried out as intended or planned while lapses are missed actions and omissions. Norman (1981) expressed slip and lapse when a worker may know that a reactor is empty and requires to be filled but he/she fills instead another similar near reactor. This scenario occurred due to confusing or poor labeling. Indeed, these failures particularly occur at the skill-based level of performance. In other words, slip and lapse are occurred in actions that have been done every day over a period of many years. HSE (1999) illustrated slip and lapse situation with six forms like:

- Routine task that does not need extensive thought,
- Confusion between the similar tasks,
- Multi-processes complex tasks,
- The main action is carried out but greater details are missed,

- Ordering of stages in a specific procedure are not tracked naturally, and
- Disturbances and troubles.

On the other hand, mistakes occur in the planning phase. Mistakes are defined as actions that are executed entirely as planned, but the plan itself is inadequate to achieve the intended outcome. Norman (1981) expressed that when a worker incorrectly expected that a reactor was endothermic and applied heat to a reactor, thereby causing overheating. This scenario occurred due to lack of knowledge or inappropriate judgement (Embrey, 2005). Mistakes can be divided into two categories based on the level of performance at which they occur as rule-based mistakes and knowledge-based mistakes (Reason, 1990). Indeed, rule based mistake describes a failure in the selection or application of problem solving rules. These problem solving rules are predefined rules that are known from experience and training. In contrast, knowledge-based mistake describes a failure of information processing capabilities of a worker while evaluating and solving a novel problem that does not have any pre-packaged rules. This form of mistake requires a solution from first principles. HSE (2016) identified several factors that may increase the possibility of making mistake by workers as the following:

- The environment of workplace: temperature, lighting, size, noise.
- Excessive task requirements: heavy workloads, repetitive tasks, high concentration and various distractions.
- Social concerns: competitiveness and peer, conflicting attitudes on OHS and few workers.
- Individual stressors: lack of sleep, drugs and alcohol, family problems and sickness.
- Equipment issues: incorrect or confusing guidelines and actions.
- Organisational problems: failing to recognise the gaps and weaknesses and to implement the required controls like assessment or training.

Apart from that, Kontogiannis and Embrey (1992) have formulated another classification structure of human error. They divided human errors into six types which are action, checking, retrieval, transmission, diagnostic and decision errors. First, action errors occur when no action is taken or the wrong action is taken or the correct action is taken but on the wrong object. Second, checking errors occur when the checks are omitted, the wrong checks are made or the correct check is made on the wrong object. Third, retrieval errors occur when information that is required is not available, or the wrong information is received. Fourth, transmission errors occur when information has to be passed onto someone else, either no information is sent, the wrong information is sent, or it is sent to the wrong place. Fifth, diagnostic errors occur when an abnormal event arises and the actual situation is misinterpreted. Finally, decision errors occur when the circumstances were considered but the wrong decision is made. In fact, 'action' and 'checking' are related to Reason's (1990) skill-based slips and lapses whereas 'retrieval' and 'transmission' errors are related to Reason's (1990) rule-based mistakes and 'diagnostic' and 'decision' errors are related to Reason's (1990) knowledge-based mistakes.

As many definitions tried to define human error variously with different purposes, it is important at this stage to define this term as it will be used in this research which will suit the current aim and objectives within the O&G industry in Bahrain taking into consideration these given definitions and discussions of human error. Additionally, the issue of violations will not be addressed in this research. Thus, human error in this research will adapt Kontogiannis and Embrey’s (1992) classification of human errors because it has more detailed and direct approaches to identify the errors in the O&G industry in Bahrain, and it is more consistent with the description and classification of human error in this industry in Bahrain. Based on all that, a human error is an unintended failure of achieving the planned outcomes in a form of action, checking, retrieval, transmission, diagnostic and decision errors. Thus, this definition has four main characteristics as there was no intention to commit an error when handling the action, this action has a particular purpose to be achieved, the action was one of the six categories, and the intended outcome of this action was not reached.

As this definition in place, it is important also to explain human factors. Thus, this concept is explained in the next section.

2.6 Human Factors that Contribute to Accidents

HSE (2016) defined human factors as environmental, organisational with job factors, and human with individual characteristics, which all affect behaviour at workplace in a way which can affect health and safety. Whereas, Mattia (2013) stated that human factor is a scientific discipline that concerns on the systematic approach of connecting human characteristics and behaviours to the work domain towards man-machine systems performance improvement and human error reduction. Human factors emphasise on enabling safe and efficient operations by optimising the performance of human in daily operations and in the face of major accident risks (DNV.GL, 2016). In other words, human factors focus on adapting technology and environment to the capabilities and limitations of workers in order to increase the safety and efficiency of systems and working practices (Zhu & Xiao-ping, 2009).

Addressing human factors in a workplace results in increasing maintainability, reliability and availability of systems used and in increasing the overall productivity and training quality in addition to reducing redesign and associated costs, accidents and human error, operational and though-life costs and staff absenteeism and turnover (Risktec, 2013). However, improving training, procedures, regulations and operating experience will affect the situation awareness of workers (Mattia, 2013). Thus, even if regulations have been proposed to improve safety these days and many advanced technologies have been installed to reduce accident, still human factors, such as inadequate and insufficient skills, are found to be at the root of the majority accident.

Regarding this explanation, rules, policies and management system are only as effective as the personnel that are implementing them. DNV.GL (2016), HSE (2016) and Mattia (2013) asserted that human factors and organisational factors lead to different failures in the workplace and they pointed that human act has a significant role in initiating, inhibiting, boosting and recovering stages of an accident. However, Baziuk, Leod, Calvo and Rivera (2015) and Mattia (2013) found that human factors that affect human reliability play a key role in daily operations and in the accomplishment of work tasks successfully. Human reliability assessment is an important concept that tends to find potential problems in human performance and to identify the influences that may affect this level positively and negatively (Anderson, 2005). Overall, understanding the factors that affect the performance of human in design and operations is a key attributor that reduces errors and increases safety performance.

Although human factors are composed human and individual characteristics, environmental factors, organisational and job factors, HSE (2012) has taken a topic-focused approach to the current important and key ten human factors topics for most industries. Managing human failure, procedures, training and competence, staffing, organisational change, safety-critical communication, human factors in design, fatigue & shiftwork, organisational culture and maintenance, inspection and testing are these top ten human factors issues. Based on the research results of the Health & Safety Laboratory (2009), which was carried to gain a greater understanding of the current behavioural and safety culture within the electricity networks sector, there are seven important human factors (National Health, Safety and Environment Committee, 2013). These factors are roles and responsibilities, competence and training, procedures, resources, top management, safety communication, and contractors. Further, Theophilus, Esenowo, Arewa, Ifelebuegu, Nnadi and Mbanaso (2017) indicated a particular collection of human factors which are safety culture, management commitment, safety leadership, organisational erosive drift, technical failure of ageing equipment and the operators' lack of knowledge or competency. Based on that, various human factors, that can affect the performance of workplaces, were identified in different scholars and there is no certain standard for categorising them.

From this broad range of human factors, the next section suggests a set of human factors which have been highlighted and proven previously in different scholars as those most influencing factors (HSE, 2012; Zakaria et al., 2012; Lu & Yang, 2010; Boughaba et al., 2014; Zakaria et al., 2012; Payne, 2011). These factors are poor role of top management (HSE, 2012; Zakaria et al., 2012; Lu & Yang, 2010), poor safety leadership (Westhuyzen, 2015; Unnikrishnan et al., 2015; Westhuyzen, 2015), poor safety culture (Boughaba et al., 2014; Rashid, 2010; Torp, 2015), poor design of workplace (Zakaria et al., 2012; Harley and Cheyne, 2005), defective machinery (Zakaria et al., 2012; Payne, 2011; HSE, 2005), ineffective reporting system (DNV.GL, 2016; Gordon et al., 2005; Anderson, 2005), improper technology (DNV.GL, 2016; Minatsevich et al., 2015; Unnikrishnan et al., 2015), stress (Galizzi & Tempesti, 2015; Abbe et al., 2011), low level of education (Baron et al., 2014; Salminen, 2011; Alli, 2008), improper training (Unnikrishnan et al., 2015; Zakaria et al., 2012; Male, 2003; Steemson, 2000) and lack of multi-professional approach (Harrison & Dawson, 2016; Baron et al., 2014; Hoefsmit, Houkes and Nijhuis, 2012).

2.6.1 Poor Role of Top Management

Poor role of top management is one of causes of accident (HSE, 2012; Zakaria et al., 2012; Lu & Yang, 2010). Actually, top management is the one who is responsible for accidents that happen in the workplace. A key feature of top management is having a good knowledge about the status of safety. Top management should have a directive path for preventing delays and overruns to projects (HSE, 2012). Additionally, believes of top management regarding safety aspect are reflected by an employee's perception of safety and how it can be valued in the workplace (Unnikrishnan et al., 2015). Based on that, top management is the party that is responsible for undertaking decisions to ensure and maintain safe functions in the entire workplace (Turvey, 2001).

However, safety policy in any workplace shows the power of top management in developing a clear feasible mission, responsibility and goal to not only establishing the behaviour standards for workers but also creating an effective safety system that modifies and directs the safety behaviour of workers (Lu & Yang, 2010). In addition, another important responsibility of top management is to develop safety-enhancing systems in the workplace and to implement a safety-oriented culture among workers (de Koster, Stam & Balk, 2011). Earlier studies like Cooper, Philips, Sutherland & Makin (1994), Krause, Seymour & Sloat (1999) and Cox, Jones & Rycraft (2004), echoed similar findings. Indeed, decisions of this level of management are important even if these decisions do not reflect their consequences immediately. In addition, right decisions of top management promote a strong safety culture that mitigate the possibility of accidents.

2.6.2 Poor Safety Leadership

Poor role of safety leadership is considered as a cause of accident (Westhuyzen, 2015; Unnikrishnan et al., 2015). Safety leadership is a cooperative and collaborative process in an organisation among leaders and workers (followers) in which leaders use their influence on workers (followers) to reach significant safety goals (Unnikrishnan et al., 2015). Safety leadership is responsible for encouraging team members to work harder and efficiently and to enhance safety performance (O'Dea & Flin, 2001). The role of safety leadership is critical in developing the ongoing pursuit of safe tasks and operations and it is a valuable personnel within a workplace who forms understandable, acceptable and practical expectations (Westhuyzen, 2015). Thus, any workplace will achieve poor safety performance if effective leadership does not exist, thereby; the O&G industry should increasingly pay attention to safety leadership.

2.6.3 Poor Safety Culture

Poor safety culture is another cause of accident. Safety culture is a part of organisational culture, which particularly focuses on affecting members' attitudes, behaviour, norms, values and personal responsibilities that draw the overall layout and proficiency of OHS in the workplace (Unnikrishnan et al., 2015). This concept was existed in 1987 in Organisation for Economic Co-operation and Development Nuclear Agency's report and specifically after Chernobyl disaster (Boughaba et al., 2014). It is what happens in any workplace when no one is watching. According to Reason (1990), safety culture is something that someone strives for it but in fact it is rarely attained. Additionally, this concept is an important safety performance indicator (Boughaba et al., 2014).

From another earlier perspective, safety culture is a product of interactions between three main factors which are individuals as psychological factors, tasks and operations as behavioural factors, and the organisation as situational factors (Cooper et al., 1994). The psychological factors tend to analyse the attitudes and views of both individual and group. While the behavioural factors assess external factors like following operation manuals and wearing personal protective equipment (PPE) that are applicable to workers in the field. Finally, the organisational factors aim to analyse business functions through the proposed policies, rules, procedures, processes and structures. Besides, an effective and sustainable safety performance is not just adhering to a checklist instead, it requires building safety culture among all workers (Westhuyzen, 2015). Recently, various industries and workplaces showed a growing interest around safety culture as it is directly associated with reducing the potential for accidents (Boughaba et al., 2014).

Rashid (2010) found that the common features of safety culture are adequate organisational communication, adequate organisational learning, high individual responsibility, and high level of management safety commitment. While Torp (2015), HSE (2013) and Turvey (2001) indicated other common attributes of safety culture as:

- Strong role of leadership and visible management commitment.
- Clear policies and procedures for managing safety.
- Clear employees' involvement.
- Good communication and realistic, understandable and acceptable goals.
- Effective organisational learning.
- High consideration for OHS issues.

2.6.4 Poor Design of Workplace

Poor design of workplace is another cause of accidents (Zakaria et al., 2012; Harley and Cheyne, 2005). According to Zakaria et al. (2012), a poor workplace layout and lack of safety features are the main examples that affect directly handling machineries and transport activities in a workplace. Thus, an adequate design and layout of workplace assist in eliminating some workplace hazards and in accomplishing work procedures safely and properly. Older workplace is more vulnerable for accidents at sudden as it has not got safe working conditions. Moreover, Harley and Cheyne (2005) have asserted that the lack of adequate design of the workplace is an important factor that may lead to accidents and it is clearly contribute to workplace safety problems.

2.6.5 Defective Machinery

Defective or dangerous machinery is one of the most common causes of accident (Zakaria et al., 2012; Payne, 2011). For example, even if forklifts have created many benefits in carrying out work activities but they resulted in numerous hazards over a number of decades. According to HSE (2005), the second major cause of accidents in the workplace is defective machinery and it has accounted yearly for about 70 fatalities. Being struck or caught in by moving machinery, falling from defective ladder, sharp edge of equipment and overturning of vehicle are some examples for that.

2.6.6 Ineffective Accidents Reporting System

Ineffective accidents reporting system is another cause of accidents. In comparison, a valuable system contributes positively to the workplace before and after the accidents (DNV.GL, 2016; Gordon et al., 2005; Anderson, 2005). An effective error reporting and handling system improves both efficiency and profitability of a workplace. Gordon et al. (2005) claimed that ineffective accidents reporting systems are presented in many industries. Therefore, these industries do not have the real picture of the conditions under which the accident takes place. Moreover, this reporting activity promotes an opportunity to review reports of recent major accidents and examine the causes of these accidents in order to provide some lessons that can be learnt (Anderson, 2005). These lessons learnt from accidents are essential to avoid accidents in the future especially in high-risk workplaces (DNV.GL, 2016).

2.6.7 Improper Technology

Improper usage of the adapted technology is a cause of accidents. Many advanced technology have been innovated, emerged and installed in many workplaces to increase the overall performance by improving the efficiency and productivity (Unnikrishna et al., 2014). According to Torp (2015), technology is used widely in the O&G industry for industrial automation and safety controlling systems. Although these technologies are key enablers in the O&G industry to solve common challenges adhered to this industry like costs and complexity, it can be ineffective if there is no systematic assessment and this could lead to major accidents and loss (DNV.GL, 2016; Paraventi, 2014). Controlling the interconnections between technologies in any workplace is a concern which should be considered because it ensures the efficiency and safety of the operations (Minatsevich et al., 2015; Unnikrishnan et al., 2015).

2.6.8 Stress

Stress is another cause of accident (Galizzi & Tempesti, 2015; Abbe et al., 2011). Stress is a body reaction an individual has when he or she is under excessive pressures or demands (HSE, 2004). From another point of view, it is a type of adverse reaction for an action, problem or pressure resulted from difference amongst the inner ability and skills and the stresses to deal with this situation (Zakaria et al., 2012). As market challenges are increasing, more stress will be added to the working conditions which lead in fact to increase employees' vulnerability (Galizzi & Tempesti, 2015; Abbe et al., 2011; de Koster et al., 2011) due to long hours of work, workload demands, and supervisory pressures. Trimpop, Kirkaldy, Athansou and Cooper (2010) pointed out that putting workers under this type of job-related stress is related positively to the increasing in the number of occupational accidents.

2.6.9 Low level of Education

Workers with lower level of education is also a cause of accidents (Baron et al., 2014; Salminen, 2011). Regarding Baron et al. (2014), workers who have lower levels of educational attainment are at greater risk of working in occupations than others are. Thus, educational level may contribute to accident in workplaces that have greater numbers of the immigrant workers. For instance, Salminen (2011) expressed that immigrant workers in Bahrain are highly exposed to occupational accidents three times more than native workers due to their lower level of education. From another viewpoint, Alli (2008) pointed out that disseminating and sharing knowledge and information among workers is one of the solutions that can solve the educational level issue in a workplace especially in developing countries. This indicates the importance of sharing knowledge and information in workplaces.

2.6.10 Improper Training

Improper training is another cause of accidents (Unnikrishnan et al., 2015; Zakaria et al., 2012; Male, 2003). The main role of training is to address many issues in workplaces and to overcome any deficiency in workplace layout (Unnikrishnan et al., 2015). Steemson (2000) highlighted different evidences and cases that showed that adequate training would have preventive role to accidents. While Male (2003) found that training critically affects different attributions like competence, education and skill development in workplaces. From Intersec's (2009) perspective, safety training is ultimately essential to assist the implementation and compliance of minimum safety standards and OHS regulations.

2.6.11 Lack of Multi-professional Approach

Lack of multi-professional approach is another cause of accidents. Harrison & Dawson, (2016)| and Baron et al. (2014) have asserted that multi-professional approach is an essential part in preventing accidents. It is a team that consists of experts to deal with physical and psychological illness and professionals in human resources management to deal with worker's home, job, and social life and to organise the responsibility and role of workers during the rehabilitation. The cost of acquiring several professionals is a potential challenge but this team is a long-term success of a workplace. (Harrison & Dawson, 2016). Nevertheless, Hoefsmit et al. (2012) explained that a multi-professional approach is one of the key factors for supporting return to work.

Based on all definitions and deliberations of human factors, human factors include three main components that can be considered as barriers or safeguards. These barriers prevent an accident from occurring and assist in reducing human error (Harrison & Dawson, 2016; Torp, 2015; Pitblado & Nelson, 2013). These components are plant and equipment, processes and people. Within plant and equipment, the design, place, modification of equipment in workplace should be in a way that mitigate human errors when any worker uses, maintains, inspects and tests these components (Pitblado & Nelson, 2013). Additionally, the impacts of the environment on the operations of plant and equipment should be considered (HSE, 2016). However, the design of plant and equipment should be built in accordance to emergency situations when the potential of errors is high (Harrison & Dawson, 2016). Technology is included also and it should be applied appropriately in the right context especially when it comes to safety.

While within processes, all procedures like method statements, work instructions, permits to work should be explained clearly and practically (Harrison & Dawson, 2016). In general, incomplete, incorrect, unclear or outdated procedures allow workers to perform more shortcuts and errors. The design of tasks and procedures should be aligned with the ergonomic requirement to overcome the gap between the required capability of tasks and human limitations and strengths (HSE, 2016). This means that there should be a strong matching between the requirement of the job and the physical and mental capabilities of individuals. Moreover, human factor should be considered through risk assessment and accident investigations. As well as, all worker should be involved in critical safety communications using a proper method of communication, language, timing and content. Organisational changes like mergers, acquisitions, restructuring, outsourcing and downsizing need to be planned and assessed to manage direct and indirect effects. These direct and indirect effects are like loss of internal professionals, ineffective standards, loss in the memory of organisation, high reliance on external parties, lack of motivated employees, inconsistent transformation in staffing levels, unstable workload, poor risk tolerance and weak process safety management philosophy (Harrison & Dawson, 2016; Pitblado & Nelson, 2013). Simply, fierce competition, deregulation and globalisation drive most of these changes. Therefore, this requires a wider thorough understanding for the emerged new risks.

Finally and within people, workers must be trained to gain safety competencies under a strong safety leadership (Harrison & Dawson, 2016). Human error should be managed and declared in relation to the impacting factors like fatigue. However, good working practices should be reinforced whereas weak working practices should be identified, recognised and lastly modified (HSE, 2016). Apart from all that, human factors describes also how the behaviour issues of all workers may lead to accidents. Human behaviour like inaccurate assessments, bad decisions and poor judgements are judged as main root causes of human accidents (Harrison & Dawson, 2016; Patel et al., 2012; Zeng et al., 2008). In other words, addressing human behaviours and attitude is largely effective in reducing accident rates by affecting numerous aspect in the workplace like management commitment to improving safety, top management visibility, employee engagement in safety and safety leadership (Unnikrishnan et al., 2015; Anderson, 2005). As a result, the focus of recent training programs have shifted from technical to behavioural by concentrating on establishing knowledge, confidence and attitudes rather than just technical knowledge to enable evaluation of skills gaps and training needs.

Having all previous discussions, Bahrain an overview on the O&G industry in Bahrain should be considered. The next section provides that.

2.7 Bahrain Overview

Bahrain is an archipelago consists of 33 islands in the centre of Arabian Gulf between Qatar and the Kingdom of Saudi Arabia (Naumann, Al-Ubaydli, Abdulla & Alabbasi, 2018; WBG, 2016; World Trade Organisation WTO, 2014; Energy Information Administration EIA, 2011; ILO, 2010). The area of Bahrain is 780 km^2 in 2015 and approximately the length of Bahraini coastlines is 126 km and the marine area is estimated to be around 8000 km^2 (The Bahrain Authority for Culture and Antiquities, 2015). The population in Bahrain was around 1.6 million in 2018 (Naumann et al., 2018). It gained independence from the UK in 1971 (OBG, 2015). Bahrain is the smallest country in GCC countries. It has attracted several empires such as the Persians, Sumerians, Assyrians, Babylonians, Arabs, Portuguese and British due to its strategic central commercial location within ancient Mesopotamia period (OBG, 2015). This commercial location allows financial institutions operating and doing business easily in Bahrain with access to the regional economy, which is worth USD1.4trn (BEDB, 2013). Nevertheless, Bahrain regionally is the oldest financial services center and it is a major offshore banking hub since the 1970s.

The principal natural resources in Bahrain are oil, gas, fish and pearls. Traditionally, pearl diving and fishing are the main industries in Bahrain's economy (OBG, 2015). They have been diminished since Bahrain started with producing oil, but they are still culturally significant. Nowadays, the O&G industry is a pillar of Bahrain's economy. Bahrain is the oldest oil producer in the Arabian Gulf (Harnek, 2014; EIA, 2011). Thus, Bahrain was the first country to discover oil regionally and in the Middle East. Referring to the historical background of oil in Bahrain, oil in Bahrain was found by Major Frank Holmes, a British officer who is known as the father of the oil, when he convinced Shaikh Hamad Bin Isa Alkhalifa to award his company an oil concession in exchange for drilling water wells. Frank Holmes found the first ever oil concession in Bahrain and after a period of time the first oil field was drilled in 1932 in the south of Bahrain (Bahrain Tatweer Petroleum Company, 2013; Hasan, Tanwar and Shah, 2009).

Therefore, in 1932 Bahrain started commencing its production by officially commissioning the first oil refinery company in 1936 which is called Bahrain Petroleum Company (Bapco). After few years, the oil was discovered in Saudi Arabia and Bapco refinery began in refining the Saudi oil which was shipped over the sea in the first stage till 1945 when the Saudi Arabia–Bahrain oil pipeline was constructed (BEDB, 2013). More details about this industry in Bahrain are provided in the next section.

2.8 Bahrain’s Oil and Gas Industry

The O&G industry in Bahrain is represented by two main fields of Bahrain's crude oil. The first one is the Bahrain Field or Awali Field which is located in the southern part of the island and the second one is the offshore Abu Sa’afa Field which is shared with Saudi Arabia on a 50-50 basis (BEDB, 2016; WTO, 2014). Actually, the strategic source of oil in Bahrain these days comes from this shared production with Saudi Arabia from the Abu Saafa oil field which is the strategic source of oil revenues (Hasan et al., 2009). Figure 2.4 represents the O&G industry in Bahrain.

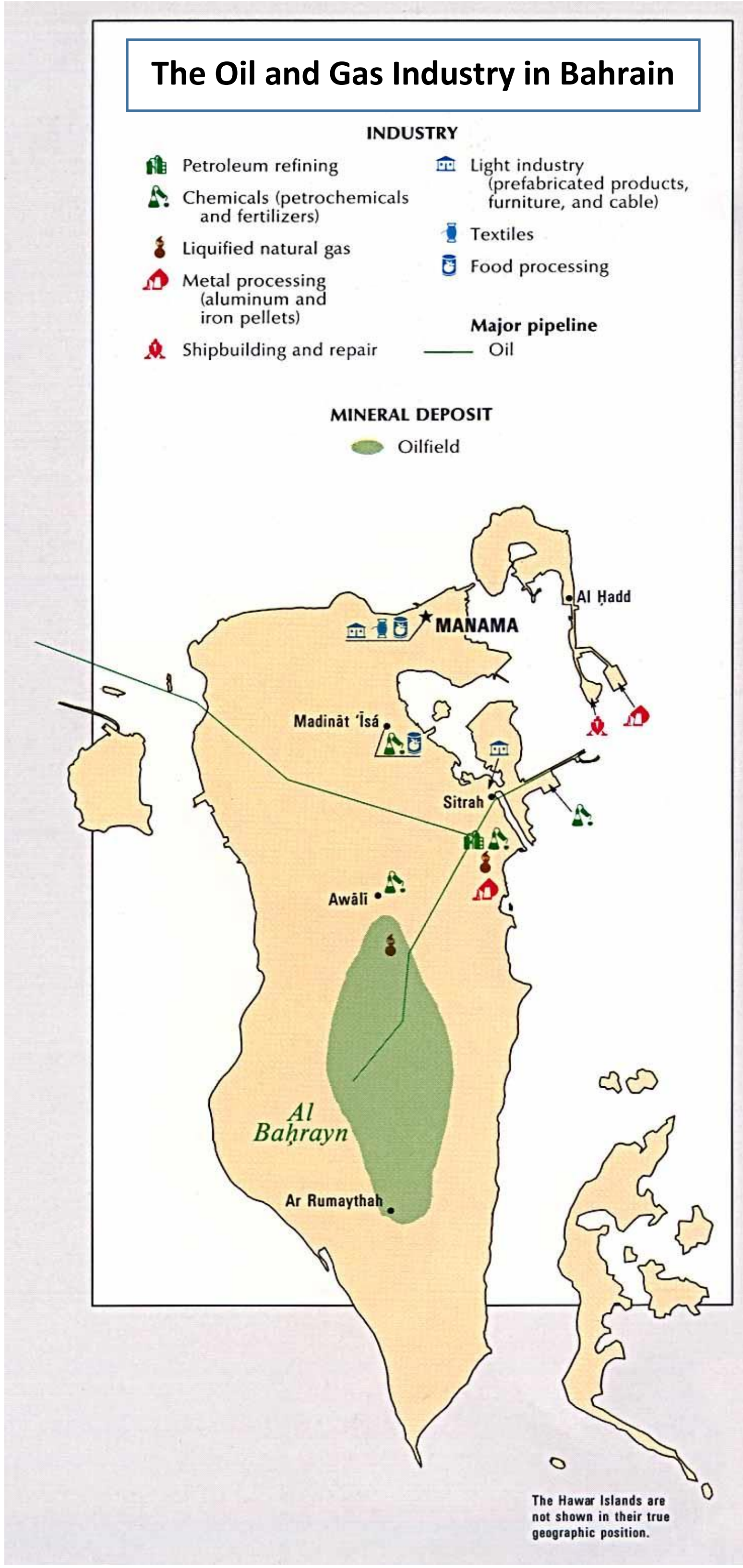

Figure 2.4: The Oil and Gas Industry in Bahrain, (Source: OnTheWorldMap, 2019)

On the other hand, the key source of natural gas and energy in Bahrain comes from the Khuff gas reservoir which is geographically near to Awali Field. Recently at the beginning of April 2018, Bahrain government has announced a large oil discovery in the western coast of the country which contains 80 billion barrels of oil in place and 13 trillion cubic feet of natural gas (Bahrain News Agency BNA, 2018; Noel, 2018). Based on experts and officials, it is expected that this new oil discovery will be on production within five years and this will have significantly raise the country profile and boost its economy. Once the production of this new discovery has taken place, this field will be one of the 30- 40 largest operating oilfields in the world (Noel, 2018).

In 2015, Bahrain produced around 250,000 barrel per day and it imported around 210,000 barrel per day from Saudi Arabia to refine it. 88% of the total output was exported as diesel, gasoline, fuel, jet, asphalt, sulfur, fuel oil and liquefied petroleum gas. The O&G industry contributes at least 80% of total government revenues in Bahrain since 2007 (Harnek, 2014; BEDB, 2013). In 2015, revenues from this industry was BHD 1, 700,787,000 which was around 81.01% of the total revenues, however, this percentage has increased to around 81.5% in 2016 (BEDB, 2016; EIA, 2011). This high percentage is a major revenue driver in Bahrain while the remaining percentage is shared between aluminum, banking, logistics services transportation, telecommunications and tourism sectors (BEDB, 2014). Bahrain is an observer of Organisation of the Petroleum Exporting Countries (OPEC). In addition, Bahrain is a member of the Organisation of Arab Petroleum Exporting Countries (OAPEC).

The economy of Bahrain depends heavily on this industry and this is reflected in the share of O&G revenues in total government revenues, the share of O&G exports in total exports and the share of the O&G industry in GDP (BEDB, 2016; EIA, 2011; Hasan et al., 2009). Statistically, it accounts for 60% of export receipts, government revenue and the financial sector, which are the largest employers and the largest contributors to GDP (ILO, 2010; Sturm, Strasky, Adolf & Peschel, 2008). The O&G industry covers the exploration, production, refining, marketing, and distribution of Bahraini oil for both domestic use and the international market (EIA, 2011). As recently this industry is a dominant of Bahraini economy, numerous developments have been undertaken like improving the educational level and developing the infrastructure. It also maintains a positive trade balance, makes public wealth and assists in moderating the consequence of the global financial crisis and downturn, sustains the current account surplus and sustains the currency peg to the US Dollar (BEDB, 2014).

On top of that, the natural gas in Bahrain is a significant source of power to the manufacturing industry and the whole country. Indeed, the entire natural gas production in Bahrain is consumed domestically (BEDB, 2016; WTO, 2014). Additionally, this industry externally is a critical global source of energy and a prime channel for crude oil and refined products in multiple world markets such as Middle East, India, the Far East, South East Asia and Africa (BEDB, 2013). Aside from these concentrations, many companies nowadays are operating in this industry in Bahrain. Examples of these companies are mentioned in the next sub-section.

2.8.1 Examples of Oil and Gas Companies in Bahrain

NOGA (2012) described that the O&G industry in Bahrain includes many different companies as follows:

- Bapco plays a main part in the downstream activities to explore and produce both O&G in Bahrain. Bapco only holds the rights to explore, drill, produce, process and distribute O&G on the behalf of Government. Further, it is also considered as a main domestic and international wholesaler in the downstream activities for O&G products.
- Tatweer Petroleum Company is authorised for exploring new oilfields in Bahrain and expanding the level of production in line with the targets set by Bahrain's Vision 2030.
- Bahrain National Gas Company (BANAGAS) is a cooperative project with Chevron and Boubyan Petrochemical in order to transfer the gas into marketable products as butane and propane.

The governance of these and other companies is too important and it should be managed accurately. Based on that the next section describes the structure of this governance.

2.8.2 Governance of the Oil and Gas Industry in Bahrain

Bahrain government retains a full monopoly over its O&G industry. In 2007, it introduced a new structure for the O&G industry by incorporating NOGA to act as a holding company (NOGA, 2012). This structure is discussed in the next sub-section.

2.8.2.1 Governance structure of the Oil and Gas Industry in Bahrain

Indeed, Harnek (2014) described that the extraction in the O&G industry in Bahrain is regulated by several Government agencies as the following:

- NOGA is a primary body that regulates, supervises, organises and develops the O&G industry in Bahrain. It is the responsible party for controlling all the process from the exploration to the production, issuing licenses and permitting third parties involved in the O&G industry. Simply it is a principal regulator with broad enforcement powers across the O&G industry.
- The Supreme Council for the Environment (Supreme Council) regulates any environmental matter in order to build environmental policies in this industry and across all other industries in Bahrain. In other words, it is responsible for adopting corrective and controlling measures to comply with HSE regulations. It is important to note that NOGA works jointly with the Supreme Council to maintain safety practices and standards compliance regarding water, air, pollution control and environmental issues.
- The Ministry of Labour is responsible for controlling and moderating any matter regarding employees' protection in all industries in Bahrain. It contacts the companies in the O&G industry like Bapco and Tatweer to ensure that the applied internal OHS policies match the international requirements.
- The Ministry of Industry and Commerce controls and manages all the industries in Bahrain. Thus, operators of all industries in Bahrain should hold a valid industrial license from this ministry. The operating rules are discussed in the next section.

2.8.2.2 Operating Rules in the Oil and Gas Industry in Bahrain

Under the control of this governance structure, operating in the O&G industry in Bahrain requires a licence or concession that should be paid based on the fee structure of that particular licence through Development and Production Sharing Agreement (DPSA). The contractors are restricted actually by several restrictions based on the type of each licence or concession. For example, regardless of the produced quantity, the contractor is legally bound to sell the oil to Bapco in accordance to the prices of Saudi Aramco for Arab Medium Crude oil. The DPSA also permits the contractor to recover production costs. However, these costs are subtracted from the value of the contractor's allocated oil. Hence, the remaining amount is the oil's profit which will be divided between NOGA and the contractor based on the predefined ratio.

Apart from that, any contractor in the O&G industry has a legal duty to meet the laws and regulations in Bahrain that concerns on OHS and HSE issues. However, any facet of breaking these regulations requires civil and criminal penalties. Moreover, more additional liabilities are imposed on the contractors if there is any harm to people. Further, Ministry of Labour imposes any contractor to employ from time-to-time Bahraini workers. Besides, by an agreement between the Minister of Health and the Minister of Labour Affairs in the Private Sector, employer must provide first aid facilities and means of emergency treatment conditions. Nevertheless, if any contractor is willing to launch a new project in the O&G industry in Bahrain, environmental impact assessment should be taken place first. By laws, the Supreme Council has the power to order a mandatory environmental impact assessment for any project or to waive that need (*Order No. 1 of 1998*) (Environmental Impact Assessment Act).

In fact, this assessment is required for particularly the downstream like oil refineries, petrochemical plants and works that produces and stores petroleum products. It takes from six to twelve months. This assessment must be developed by accredited consultancy firms (*Order No 3 of 2000*) when it is applied in the O&G industry. Then, the Supreme Council must take into account OHS issues and ecological influences by conducting further research, studies, tests, analyses and assessments. Lastly, the Supreme Council issues its views and recommendations and the applicants are expected to act on these recommendations. On top of these rules and restrictions, there are some general OHS orders and concerns in Bahrain that add more restrictions to this industry. These Orders are explained in the next section.

2.8.2.3 Occupational Health and Safety legislations and Orders in Bahrain

In 1976, Bahrain established the first OHS legislation based on the UK Health and Safety at Work Act 1974. This legislation provides the necessary precautions to protect workers from the hazards and risks raised from working activities (Matooq & Suliman, 2013b; Alaradi, 2010). The legislation consists of 30 Ministerial orders to regulate and control OHS at workplaces in Bahrain. Operations safety, management of OHS, fire prevention and health and welfare are some areas of these orders. Chapter 18 of the same law involves the term of labour inspection along with a description of the power of the appointed inspectors. However, rapid development and modifications in Bahrain economy led MOL and Social Affairs to establish a safety unit called the Occupational Safety Section as a part of the Labour Directorate. In fact, this unit consists of several engineers and specialists who are responsible for only carrying out safety awareness programs among the public and it had nothing to do with enforcement (Matooq & Suliman, 2013b). On a positive move, further orders were issued since 2000 regarding first aid, workers' medical surveillance and workers' protection from fire (Alaradi, 2010). Although several recent orders were passed in 2006 and 2005, the majority of these orders were dated from 1976 or 1977. Examples of orders are provided in Table 2.1.

Table 2.1: Examples of OHS Orders in Bahrain

Orders	Description
Order No. 23 of 1976	Proposed to protect workers from the hazards and risks raised from working activities. Labour inspection.
Order No. 15 of 1977	Proposed to ensure that operators develop and apply control measures (precautionary and preventative) to mitigate the potential of risky mechanical equipment.
Order No. 21 of 1996	Proposed to preserve and protect the environment.
Order No. 10 of 1999	Proposed to affect the O&G industry and it closely concerns on the industrial emission of pollutants in the air or water.
Order No. 6 of 2000	Proposed to protect employees along with general principles for safety.
Order No. 3 of 2005	Proposed to ensure that operators provide an adequate working conditions with appropriate environmental standards and conditions including minimum standards for lighting, temperature, noise and vibration limit.
Order No. 3 of 2006	Proposed to express how to deal with hazardous waste that has a negative effect on people, environment and wildlife in Bahrain.
Order No. 10 of 2006	Proposed to keep recording chemical emissions and launch several technologies that allow the Supreme Council to internally access to emission levels information electronically.
Order No. 8 of 2013	Proposed to regulate OHS in establishments.

Turning to the general OHS issues for the O&G industry, Bahrain legislations and orders are applied to all industrial sectors with both private and public entities. However, there is no ongoing dedicated orders for the processes in the O&G industry for instance during the exploring, drilling and processing of O&G and even for the construction and operation of O&G pipelines. Most of these orders are general for all types of industries. For example, (*Order No. 15 of 1977*) was proposed to ensure that operators develop and apply both precautionary and preventative control measures to protect workers from particularly the risky mechanical equipment. In addition, in term of protecting employees, general orders for safety are proposed in the Industrial Safety order (*Order No. 6 of 2000*). It indicates that an operator in the industrial sector should:

1. Appoint an adequate and qualified OHS manager to ensure that all employees are committed to the proposed internal standards of safety.

2. If any workplace that involves over 100 employees, an operator must set up an OHS committee to develop safety practices, policies and protocols for employees.

3. Ensure an adequate level of employees' safety awareness.

4. Ensure that there is frequent safety training for all employees on safety best practices.

Further, *order No. 3 of 2005 was proposed* to ensure that operators provide an adequate working conditions with appropriate environmental standards and conditions including minimum standards for light, heat, noise and vibration level. As well as, environmental issues are addressed also in several earlier orders. These issues were in the Environment Act (*Legislative Decree No. 21 of 1996*). The Supreme Council is the power that controls and prohibits any action, chemical, or material that may cause contamination, pollution or harm to ecosystem in Bahrain. Similarly, the Standards of Air and Water orders (*Order No. 10 of 1999*) was proposed particularly to focus on the industrial emission or discharge of pollutants into either the air or water.

Thus, the Supreme Council also forces all operators in public and private institutions to comply with (*Order No. 10 of 2006*) by launching several technologies that allow the Supreme Council to be connected electronically with chemical emissions information at any time. Waste as well is considered in this point in which the operators must communicate with the Supreme Council and the Ministry of Municipalities regarding transporting and storing and disposing wastes. Hazardous Wastes order *(Order No. 3 of 2006*) is particular expressed how to deal with hazardous waste which contains any types of material that has a negative influence on people and the overall environment.

Although there are some health and safety orders in Bahrain, Alaradi (2010) pointed that there are also number of difficulties that drive the need for more accurate OHS legislation, regulations and procedures in Bahrain. He indicated that lack of safety professionals is a main difficulty in Bahrain especially during the current conflict between market trend and OHS regulations. Thus, many workplaces do not recognise their current need in terms of safety aspects and training and their management does not really realise the consequences of accidents or the ways to reduce the possibly of accidents. Second, he found that the number of occupational accidents in different industries in Bahrain is increasing. Although OHS legislations and orders in Bahrain are increasingly tough, Bahraini laws are not as strong as the enforcement of the UK Health and Safety at Work Act 1974 that is built on (Alaradi, 2010). In other words, the existing penalties for infringement in Bahrain are inappropriate in discouraging weak safety practices. As well as, although Bahrain enforces any employer to provide any new employee with a training, Alaradi (2010) stated that the offered training courses are restricted by several numbers of trainees and by a very lengthy process and delay of daily procedures.

Apart from the challenges of these orders, Bahrain is facing various challenges and difficulties that restrict the overall performance of OHS in the O&G industry in the country. These challenges are illustrated in the next section.

2.9 Challenges in the Oil and Gas industry in Bahrain

Based on the boundary of each challenge, challenges in the O&G industry in Bahrain can be classified into three main sections as developing countries challenges, petroleum countries challenges and marketing challenges. These challenges are discussed in the next sub-sections.

2.9.1 Challenges as a Developing Country

Bahrain as a developing country that operates in today globalised market is enforced to operate among several regions and countries. As a result, a new challenge that has not been investigated in the O&G industry is initiated to propose more sophisticated accident prevention programs and OHS management systems taking into account cultural differences (Lindoe, Baram & Renn, 2014; Hassanzadeh, 2013; Hamalainen et al., 2009). Furthermore, the complexity of the required instrumentation, regulatory regime, expertise and technology in the O&G industry, the nature of the impact of the products, by-products and waste products on OHS of employees and environmental issues are main questions in this industry especially aligning with the global trend for a safe and friend environment (Achaw & Boateng, 2012).

Additionally, although the statistical data is a starting point for any safety work it was noticed that occupational accidents statistics in the O&G industry are published annually in many countries but having reliable and standardised data is a challenge (Ho, Hwang & Wang, 2006; Konstandinidou, Nivolianitou, Markatos & Kiranoudis, 2006). Indeed, data of occupational accidents is not standardised in general and it is not reliable in specific in developing countries for example Bahrain due to their poor notification and recording systems. The O&G industry and especially in Bahrain does not have a standardised accidents reporting system and instead companies in this industry tend to develop or purchase their own specific systems (Gordon et al., 2005). Macedo and Silva (2005), Ho et al. (2006) and Konstandinidou et al. (2006) confirmed that official numbers of occupational accidents are missing for different nations.

Aligning with the lack of suitable recording and notification systems, Hamalainen et al. (2009) claimed that as the demand for effectiveness and efficiency is increasing continuously at company and country levels, the direct and indirect costs of an occupational accident is another facet of problem confronting the O&G industry in developing countries because this requires a specific compensation and social security systems to generate special economic calculation. As per the O&G industry in these countries, Marcella et al. (2011) have concluded that better OHS regulations, greater consistency, better safety standards and better enforcement are required due to several reasons. Lack of openness and sharing across management, lack of robust safety assessment, lack of agreement on competence measurement techniques, lack of accurate training programme and the confusion between providing accurate safety training and obtaining just certifications in order to build a competence environment are some reasons.

The challenges as a developing country are summarised in Figure 2.5. The next section explains other different facts of challenges regarding the petroleum countries.

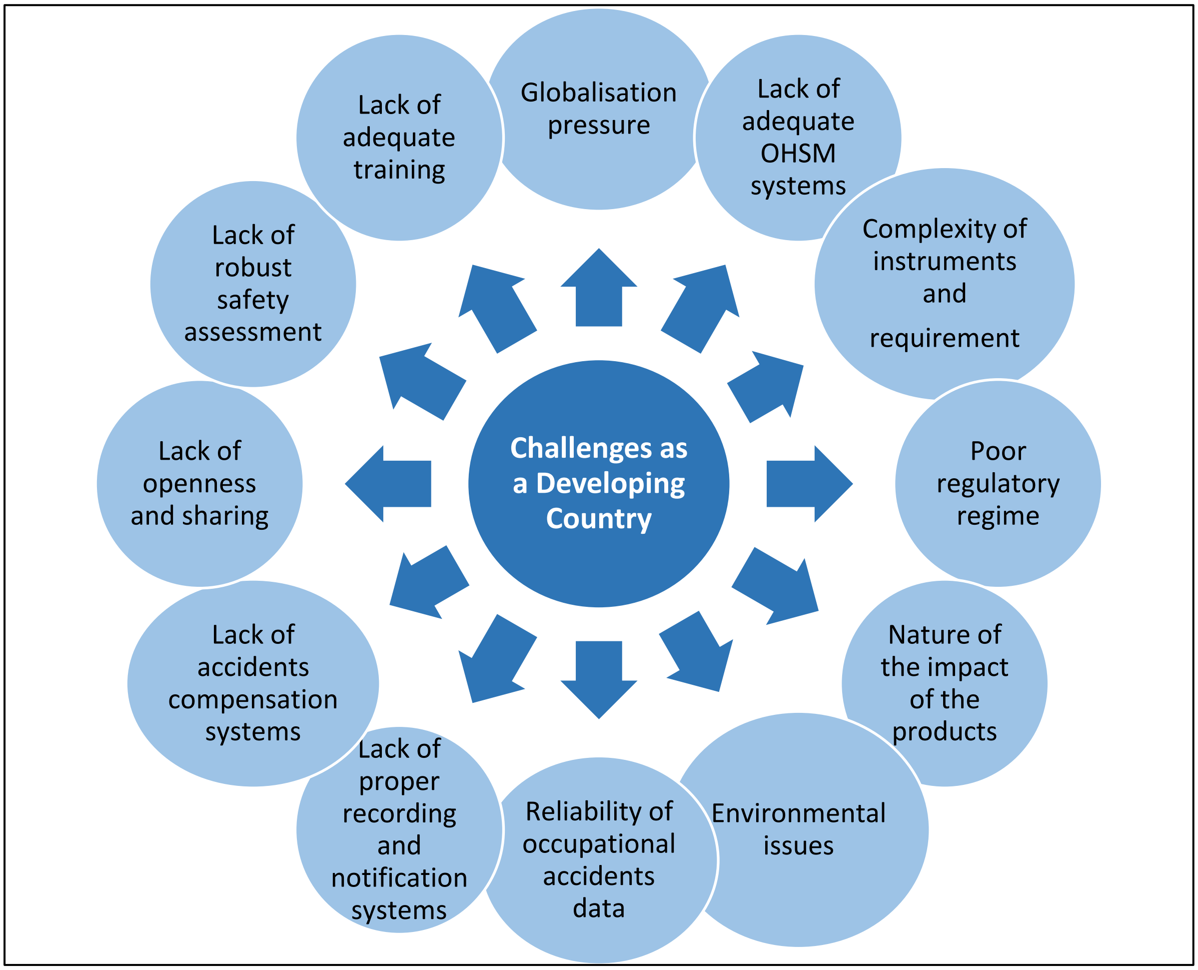

Figure 2.5: Challenges as a Developing Country

2.9.2 Challenges as a Petroleum Country

Bahrain as a petroleum country is confronting with several OHS related problems regarding their economy and nature. For example, there are limited integrated researches on the region's long-term institutional and sectoral development; thereby, its long-term geoeconomic significance is missed (AlBanna, 2002; Matooq & Suliman, 2013a, b). However, details of the occurred occupational accidents in GCC countries are seldom recorded and this may be explained by likelihood of recording bias (Barss et al., 2009; Matooq & Suliman, 2013a). In 2007, the MOL asked NEBOSH to carry out a review on OHS legislations, regulations, standards and enforcement structure in Bahrain. The output showed that OHS framework needs some redesigning plans such as the national framework, legislations and enforcement policies.

Despite the fact that Bahrain a risky industry like the O&G industry that it depends on, the published accidents data in Bahrain from this and other workplaces does not contain a lot of data about the root causes of these accidents and it is too hard to communicate them to the OHS violence after the investigation is closed (Matooq and Sulima, 2013b; BNA, 2013). Thus, this argument asserted AlBanna's (2002) findings that the published OHS accidents statistics in Bahrain do not reflect the actual situation of OHS. However, Matooq and Suliman (2013b) have confirmed that in their research by reviewing the status of OHS framework in Bahrain. They found that OHS framework is not suitable now to depend on due to the lack of accident data and the different definitions approved by the concerned parties.

They found that as there are two parties for collecting accidents data in Bahrain which are MOL and SIO having their different aim, definitions for OHS accident, procedures and objectives. MOL collects accidents data for investigation purposes and for taking necessary legal actions against any offenders to the OHS rules and regulations, whereas, SIO collects the data for compensation purposes. Due to this isolated recording work, there is a considerable difference between the accidents statistics published by MOL and the ones published by SIO. Nevertheless, they found that this drawback is related to the absence of sufficient punishment in both MOL and SIO system during the last few years.

Nonetheless, unfortunately by revisiting the decisions taken by the OHS inspectors of MOL during 2006-2009 in Bahrain, Matooq and Suliman (2013b) found that an average of 24% of yearly prosecution notices were changed or cancelled due to two main reasons. The first reason was the conflict between decisions of the chief inspector and the inspector decisions. In addition, this showed that there was no control of discretion made available to OHS inspectors. The second reason was the unsatisfaction of employers regarding the enforcement actions which led employees to raise complains to the management of the ministry. The second reason showed that decisions taken by the inspector were changed or cancelled with an agreement of the top management without any base or criteria for these changes.

In summary, Matooq and Suliman (2013b) concluded that there is an absence of standardisation, consistency and fairness during the inspection work carried by OHS inspectorate in addition to the low level of trust between the inspectorate and employers. Further, they concluded that safety regulations and procedures related and the enforcement activities in Bahrain needs strongly redesigning and development as they formed 30 years ago. Indeed, the findings of Matooq and Suliman (2013b) asserted NEBOSH's findings which all have indicated that Bahrain OHS Framework requires to promote fairness and transparency in enforcement decisions to the stakeholders. It is important to note that consistency, transparency and fairness are major components of an adequate enforcement of law and regulation as International Labour Organisation's Occupational Safety and Health Convention No. (155) has stated.

The challenges as a petroleum country are summarised in Figure 2.6. Apart from all above challenges, there are other challenges that should be addressed based on the market dynamics. These challenges are mentioned in the next section.

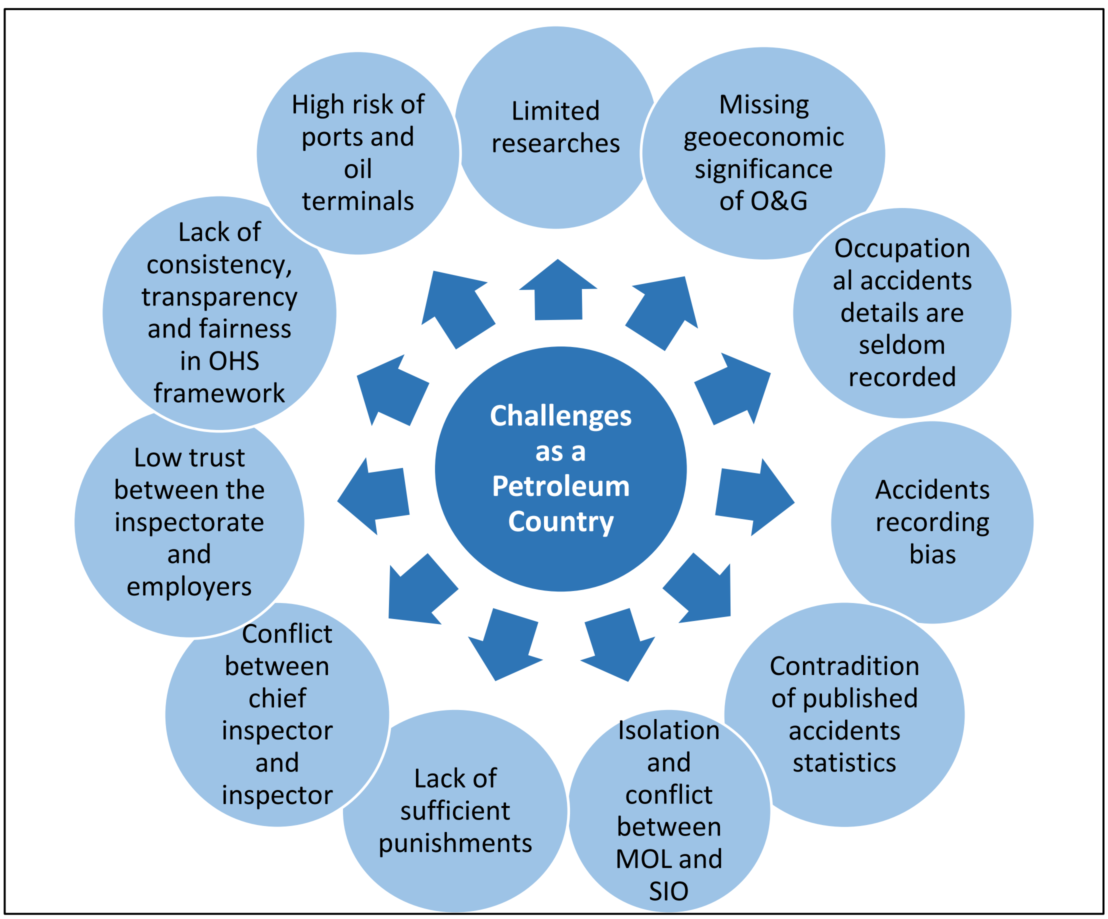

Figure 2.6: Challenges as a Petroleum Country

2.9.3 Market Challenges

Despite the development and growth of the current market, the current political, economical and social issues globally and regionally pursue a wide range of challenges to the O&G industry in Bahrain (BEDB, 2016). The strategic pressure is to meet future demands fluctuates in oil prices aligning with responding to the requirements of the regulatory bodies in the O&G industry locally and globally. Particularly oil prices and currencies have been described by considerable volatility and uncertainty in the global economy in 2015. Due to that, the oil price correction in Bahrain economy is necessitating steps toward fiscal restructuring while the regional economies continue strengthing the non-oil growth drivers. Apart from that, although the global economic is experiencing a downturn since 2009, Bahrain continues the rapid development and remains the headline growth robust in response to high demands on their production and expansion (Yaqoob, Naser, Elkanzi & Janahi, 2019; BEDB, 2018; Neave, 2010). According to Ferroukhi, Doukas, Androulaki, Menichetti, Masini & Khalid (2013), the rapid growth in population and economic in Bahrain is highly increasing the annual energy demand by 10%.

However, this demand is forecasted to increase over the coming decade. The Economist Intelligence Unit (EIU) (2009) expected that GCC countries will account for one quarter of the total world's crude oil exports by 2020 in addition to an increase of about 7% in the coming 10 years. This means that these countries have to increase O&G industry's production and increase the refined products and petrochemicals even if the global economy is facing this risky setting. Aligning with oil prices pressure, the O&G industry in Bahrain is facing the pressure to comply with international OHS policies and standards, to address safety and environmental concerns and commercial issues and to respond to safety regulations and legislation in Bahrain.

Overall, the effect of this pressure is increasing because Bahrain concerns on generating its main revenue from O&G resources instead of improving OHS standards while at the same time other industrialised countries are contemplating the importance of OHS laws (Neave, 2010). Bahrain should concern on that precisely as its ports and oil terminals are at high risk of major oil spills and accidents and as its current health and safety legislations need more improvements (Naser, 2011). However, ILO (2010) indicated that Bahrain needs a single government agency to develop a particular safety strategy to address legislations and enforcement weaknesses and to improve the overall safety performance. Simply, Bahrain at present have to open eyes to major clashes rise between production and OHS. However, another local challenge presents during this uncertainty setting in the last few years which is the rapid rising in the consumption of petroleum products by domestic that reached 9.4 million barrels (WTO, 2014). All market challenges are presented in Figure 2.7.

Figure 2.7: Market Challenges

In summary, the O&G industry in Bahrain is facing numbers of challenges. Examples of challenges as a developing country are like

1. Globalisation pressure.
2. Need for sophisticated OHS management systems that consider cultural differences.
3. Complexity of instrumentation, regulatory regime, expertise and technology.
4. Nature of the impact of the products, by-products and waste products.

5. Environmental issues.
6. Reliability and standardisation of occupational accidents data.
7. Lack of proper recording and notification systems.
8. Lack of accidents compensation and social security systems.
9. Lack of adequate and consistent OHS regulations, safety standards and enforcement.
10. Lack of openness and sharing across management, robust safety assessment, agreement on competence measurement techniques and accurate training program.

While examples of challenges as a petroleum country are like

1. Limited researches in this industry.
2. Geoeconomic significance of O&G is missed.
3. Details occupational accidents are seldom recorded.
4. Accidents recording bias.
5. Needs for redesigning plans for OHS framework.
6. Published accidents data does not contain a lot of data about the root causes of accidents.
7. Published accidents statistics do not reflect the actual situation of OHS in Bahrain.
8. OHS framework is not suitable.
9. Isolation between MOL and SIO recording work.
10. Conflict between MOL and SIO in the aim and definition of OHS issues.
11. Absence of sufficient punishments.
12. Conflict between decisions of the chief inspector and the inspector decisions.
13. No control of discretion made available to OHS inspectors
14. Unsatisfaction of employers regarding the enforcement actions.
15. Low level of trust between the inspectorate and employers.
16. Need for consistency, transparency and fairness in OHS framework.
17. Ports and oil terminals in Bahrain are at high risk of major oil spills and accidents.

Finally, examples of market challenges are like

1. Rapid growth of market, political, economical and social issues.
2. High internal and external demands.

3. Fluctuation in oil prices.
4. Pressure of the global and local regulatory bodies requirement in the O&G industry.
5. Needs for a single government agency for legislations for this industry.
6. Clashes rise between production and OHS requirement.
7. Increased domestic consumption of petroleum products.

Based on all points in this section, the O&G industry is facing many challenges. Regarding the ongoing concerns of the economic crisis and other challenges, Bahrain has undertaken particular actions and implemented several policies to respond to these challenges and market's trends, meet OHS regulations, control their risks, manage their performance, and precisely control their budgets through reducing accidents and costs in order to achieve typical results. These actions are clarified in the next section.

2.9.4 Actions Taken in the Oil and Gas Industry in Bahrain

Bahrain has taken number of steps to address these challenges. Bahrain has become a member of the WTO and has joined in different free trade agreements like the Free Trade Agreement with the U.S. and the Gulf Common Market (ILO, 2010). These agreements are considered as steps to increase labour reforms by expanding its private sector that opens door for nationals' employment, increases productivity, builds modern open market economies, and becomes less reliant on foreign labour. Furthermore, several new investments and competing projects are being planned or have recently been completed in the O&G industry in Bahrain to increase oil production and overhaul power generation. Additionally, the O&G industry launched a governmental policy to consolidate the oil industry through further development in petroleum resources, improvement in seismographic surveys, and enhancement in developmental drilling which all lead to explore new sources of O&G (WTO, 2014). Thus, the efforts are now devoted to double output from O&G fields by 2020 (BEDB, 2016). For example, Tatweer Petroleum Company was incorporated to reverse the declining trend and to leverage the output at Bahrain Field through increasing the drilling activities to find new oil wells and by utilising from the advanced oil recovery techniques (BEDB, 2013; Hasan et al., 2009).

In line with these efforts, Bahrain and Saudi Arabia have agreed on a plan that tends to replace and expand a 112-km oil pipeline that connects the two countries by 2011 in order to widen the flow of crude oil to Bapco (BEDB, 2018; Hasan et al., 2009). This project commissioned as a joint venture between the two state-owned companies, which are Saudi Aramco, and Bapco to meet the recent burgeoning demand on O&G (Rousseau, 2018). The AB-4 pipeline can transport up to 350,000 barrels of oil per day and it is divided into three segments which are 42km onshore Saudi segment, 28km onshore segment in Bahrain, and a 42-km offshore segment (BEDB, 2018). Additionally, three main projects were launched in 2014 in the O&G industry including Liquefied Natural Gas (LNG) project which is the third natural gas processing train for BANAGAS, the $9bn Sitra Refinery upgrade and building of a new power plant. Indeed, building a new refinery project involves an expansion of the AB Pipeline's capacity from 230,000 bpd to 350,000 bpd that is projected to cost as much as $9bn. In 2018, Bahrain started a new project called Bapco Modernisation Program (BMP) to redevelop Bapco refinery to remain competitive in the 21st Century (Paci & Booth, 2018; Bhatia, 2019). This project will raise the Sitra refinery's capacity to 350,000 barrels per day pipeline from the current capacity of 267,000 bpd by the end of 2022 (Bhatia, 2019).

On top of that, Bahrain is aiming to boost gas production. This project will increase the overall gas production from 1.5bn to 2.5bn cubic feet/day (CFD) by 2020 by building additional onsite electricity generation and the development in other local industries (BEDB, 2013). A summary of these recent strategies and plans is provided in Table 2.2.

Table 2.2: Recent Strategies and Plans in the Oil and Gas Industry in Bahrain

Recent Strategies and Plans in the Oil and Gas Industry in Bahrain
• Became a member of WTO and Free Trade Agreement with US.
• Doubling output from oil and gas fields by 2020 through Tatweer.
• Replacing and expanding a 112-km oil pipeline connecting Bahrain and Saudi Arabia.
• LNG project for BANAGAS.
• Upgrading Sitra Refinery.
• Building a new power plant.

It is important to note that although these projects have been undertaken in the recent years and notable improvements have presented, accidents and human errors are still common in this industry. The next section expresses that broadly.

2.9.5 Accidents and Human Error Challenges in the Oil and Gas Industry in Bahrain

As mentioned before, the O&G industry in Bahrain has undertaken different projects in recent years and notable improvements have presented. Indeed, these projects have several shortcomings regarding OHS aspects like inadequate evaluation of impacts on workers, workplace and environment, neglecting cumulative and long-term effects and insufficient treatment for monitoring measures (Naser, 2011). In this regard, Paci & Booth (2018) confirmed that there is no specific regulation in OHS framework in Bahrain regarding assessing the cumulative impacts of the development projects in the O&G industry. Barss et al. (2009) concluded that workers in Bahrain are now in hazardous occupations because these rapid economic development projects involve large numbers of expatriates who outstripped the capacity of the country to train and set up adequate numbers of industrial hygienists and safety inspectors. As such, Alaradi (2010) indicated that there is a rising tide in the total number of occupational accidents in Bahrain in the workplaces of heavy industries including the O&G industry.

On the other hand, different researchers, like Madany et al. (1994), Madany et al. (1998), De Mora et al. (2004), De Mora et al. (2010), Naser (2011) and Freije (2015), have remarked that some mistakes during several operations and maintenance activities that were done by workers in the O&G industry in the coastal areas of Bahrain were the primary causes of accidents in this area. However, these accidents led to oil spillages which have strategic effects on people, workplace and environment. For instance, these mistakes of the O&G industry were behind the increased level of hydrocarbon concentrations in this place (Madany et al., 1994; De Mora et al., 2004; De Mora et al., 2010; Naser, 2011; Freije, 2015). Additionally, all these researches confirmed that these accidents and mistakes in this industrial area create the highest pollution concentrations of the hydrocarbon in GCC countries due to continuous human interventions to transport oil and clean oil tankers.

However, Al-Saleh, Al-Doush & Echeverria-Quevedo (1999), Sheppard, Al-Husiani, Al-Jamali, Al-Yamani, Baldwin, Bishop and Jones (2010) and Naser (2011) have noticed an escalating in human activities in the area of the O&G industry in Bahrain which have several negative effects on human, workplace and environment in Bahrain. Therefore, Naser (2011) has highlighted the importance of improving worker's understanding regarding the negative impacts of their mistakes in such risky workplace. As well as, Madany et al. (1998) pointed out that a continuous monitoring in these risky areas in Bahrain is of paramount importance because of its long-term adverse effects on a worker's OHS in addition to the work environment. Nevertheless, Naser (2011) concluded that Bahrain is under a permanent threat from the O&G industry as Bahraini ports and O&G terminals are at high risk of major oil spill incidents. For example, in 2000 this industry in Bahrain had recorded six oil spills, including leakages in pipelines, over flooding of containers, weathered oil and tarballs, and accidents during loading of tankers in the terminals. A summary of this scenario is showed in Table 2.3.

Table 2.3: Consequences of Recent Strategies and Plans in the Oil and Gas Industry in Bahrain

Consequences of Recent Strategies and Plans in the Oil and Gas Industry in Bahrain
• Inadequate evaluating of impacts on workers, workplace and environment.
• Neglecting cumulative and long-term impacts.
• Insufficient treating for monitoring measures.
• Outstripping the capacity of Bahrain to train and set up adequate industrial hygienists and safety inspectors.
• Increasing the need for greater OHS legislations and orders.
• Increasing the need for greater environmental protection laws.
• Increasing the possibility of human error.
• Increasing the accident rate.
• Increasing level of hydrocarbon concentrations and pollution.
• Increasing the possibility oil spills.

Having all that, the next section discusses best safety practices in the O&G industry in the developed and industrised countries.

2.10 Best Safety Practices in the Oil and Gas industry

The O&G industry should give safety a top priority and continually strive to build upon its record of safety (Westhuyzen, 2015; Clark et al., 2013). Thus, the O&G industry should be committed to developing standards and best practices that are needed to create this safety and to supply consumers with the required energy safely, efficiently and with the lightest environmental footprint possible (American Petroleum Institute API, 2016). Although there is no universal solution that fits all workplaces as each workplace has its unique size, complexity and structure, efforts to gather some fundamental common OHS issues and best practices in the O&G industry are required (Achaw and Boateng, 2012). Adapting best practices is an opportunity to take advantage from a good experience of others and learn more about a specific context in order to develop effective and pragmatic OHS and environmental implementations.

These best practices ensure that people and environment are protected, assets are managed, competency is maintained and the risk of lost production is reduced (Risktec, 2016). In addition, developing a formal safety case called best practice ensures that all workplaces adhere to the same restriction rules and standards for safety, environmental protection and other critical aspects of industry operations (Risktec, 2016). It is important to note that the attention for developing best practices that consider human errors in the industrial sector mostly involves the biopharmaceutical manufacturing and pharmaceutical cleanrooms (Chalk, 2012) but not the O&G industry. The next sub-sections express some examples like best practices guidelines of HSE (2006), best practices of ISHN (2014) for the O&G industry, best practices of Kenyon (2014) for the O&G Industry, best practices of Risktec (2016) for the O&G Industry and best practices for Paraventi (2014) for the O&G Industry.

2.10.1 Best Practices Guidelines of Health, Safety and Executive (2006)

HSE (2006) in UK has outlined a framework for a best practice that focuses on keeping open eyes on several important aspects in the workplace to get some fruitful long-term benefits. This best practice is for public sector bodies and workplaces in general regarding OHS governance consisting of seven main principles covering:

1. **Director competence:** Top management know clearly the current strengths, weaknesses, challenges and other issues related to OHS in the workplace in order to align the exact needs in term of knowledge and skills.

2. **Director roles and responsibilities:** Top management is legally the first responsible party for the governance of key OHS issues by developing an effective OHS framework including safety policy and strategy, safety standards and key safety values by adapting several controls and measures for the overall OHS performance. They should ensure a good OHS performance.

3. **Culture, standards and values:** Top management should build a sound open culture across the workplace by increasing both the external and internal communication on OHS matters.

4. **Strategic implications:** Top management should drive the OHS plan, identify OHS threats, opportunities and market forces and ultimately establish a response strategy.

5. **Performance management:** Top management should set out first the main OHS management's objectives and targets and then build the required incentive structure to drive the aim of achieving a high OHS performance.

6. **Internal controls:** Top management should identify, assess, manage, control risks and hazards in the workplace and should ensure a strong compliance with the essential safety standards. They should ensure also the quality of the internal OHS control and auditing process.

7. **Organisational structures:** Insufficient governance of the organisation may lead to accident, financial losses, unhealthy and unsafe working environment and a high number of work-related ill-health, sickness and absences. Therefore, there should be a demonstrable linkage between improved share price and good OHS performance.

In summary, the previous best practices emphasise on redesigning clear components in and around the workplace environment that are critical to reduce accidents. Redesigning is one of easy and cheap way to adjust the conditions in a workplace rather than adapting new equipment or tools which requires more additional costs for example for installation, testing and training.

2.10.2 Best Practices of Industrial Safety Hygiene News (ISHN) (2014) for the Oil and Gas Industry

The O&G industry nowadays has started to recognise the importance of sharing OHS lessons learned and best practices as well. For instance, ISHN (2014) in UK found 20 best practices that are applicable in the O&G industry and have recorded a clear enhancement. These best practices are:

1. **Click it:** As vehicle crashes due to not wearing Personal Protective Equipment (PPE) resulted in high numbers of accident to workers in the O&G industry, **'**Click it' practice that concerned on ensuring that all vehicle riders in every seat buckle up and follow the seat belt tips and guidelines could reduce significantly these statistics.
2. **Pre-screen employers**: The recruitment procedure for any new/prospective employees in the O&G industry should assess and screen the quality of skill levels and experience of the candidates by including several questions that identify and demonstrate their previous safety commitment on-the-job safe behaviours in the workplace.
3. **Leadership:** Safety leadership should be visible, involve in safety matters and demonstrate their commitment to safety, OHS framework, safety compliance and safety behaviour. They should constantly promote safety and safety best practice in the workplace.
4. **Train safety leaders:** Safety and operation best practices capability development programs are held yearly with approximately 9,500 of attendees. These programs provide safety leadership with the required skills and tools to operate safely and consistently. These programs can be like 'Leaders in the Field' which is an onsite practical training with real engagement with workers to ensure safe processes and functions. And it can be like 'Operating Essentials' that concentrate on operating issues, such as risk assessment and process safety, by developing interactive, cross-functional programmes and workshops.
5. **Healthy workplaces**: Applying several fitness campaigns in the workplace like 'Run-A-Muck' encourages workers to present, sustain or develop the amount of physical activity they handle daily.
6. **Contractor safety**: British Petroleum tends to build strong and reliable guidelines of its contractors. For example, in British Petroleum's (BP) upstream, considering safety, health,

security and environment requirements are utmost important components in the contract standard model. Sometimes further documentations and reports are required to compare between British Petroleum's safety management system and contractors' risk controls and systems. In other more hazardous cases, additional information and documents are needed as technical and health, pre-contract quality, security, safety and environmental audits and standard performance metrics.

7. **Safety culture**: Zero accidents strategy is a strategic prevention plan proposed by Chevron in US for more than 20 years. It concentrates on building safety culture by tracking and awarding business units that have higher safety performance, sharing best practices and lessons learned and using safety behaviour-based evaluations. In line with building this safety culture, Chevron has prohibited using any electronic devices like cellphones during driving vehicle since 2003.

8. **Emergency preparedness**: ConocoPhillips introduced four main emergency preparedness response exercises applied to three lands in 2013. The total number of people who participated in these lands and with the ConocoPhillips Global Incident Management Assist Team (GIMAT) in U.S was 1,000.

9. **Exposure assessment**: ConocoPhillips in US has developed 'Exposure Assessment Plan' to identify, assess and control workplace hazards. It should be adapted in each unit and for employees and contractors in order to minimise exposure risks to all these elements. It determines all types of risks that workers may be exposed to in day to day activities. This process takes advantage from OHS and industrial hygiene performance metrics to check whether the chemical risk identification processes, protection controls and medical examinations of worker health are effective or not.

10. **Keep it simple**: ExxonMobil Pipeline Company in US has its simple health and safety performance goal that expressed that "Nobody Gets Hurt." This vision is achieved by formulating safety policy that indicates that all stakeholders are responsible for maintaining a safe workplace and accurate and clear safety procedures. It ensures also that all operations and maintenance activities are undertaken in accordance to the predefined safety policy, standards, rules and regulations.

11. **Management systems**: Operations Integrity and Management System (OIMS) was proposed by ExxonMobil to manage all daily operating decisions. It has 11 components as

management leadership, commitment and accountability; information/documentation; risk assessment and management; community awareness and emergency preparedness; facilities design and construction; operations and maintenance; personnel and training; management of change; third-party services; incident investigation analysis and operations integrity assessment and improvement.

12. **Management of change**: As introducing any change in the workplace requires dealing with different factors, ExxonMobil developed a checklist to address any change. This list indicated that any changed should be approved, compiled with current standards and regulations, acquired the required permits, documented by covering reasons for this change, and should develop operations integrity implications analysis, risks assessment, mitigation measures and associated training. However, this change should be developed within the planned duration.

13. **Maintenance**: ExxonMobil's operating, maintenance and inspection procedures consider critical activities, operations, regulations, environment and human factors. For example, it develop a work permit process to check and authorise the consistency with mechanical and operational risks. It has also mechanical integrity programs for all equipment to provide an effective test, inspection and maintenance.

14. **Fire safety**: In 2013, Saudi Aramco introduced "Smoke Detector Awareness Campaign" that strives to increase the installation and use of smoke detectors.

15. **Wellness**: Due to the importance of a healthy worker, Saudi Aramco launched "Wellcare" programme that focuses on enhancing OHS issues related to both employees and workplaces. The programme is available online and on-site. It covers health improvement, physical exercises sessions, lifestyle and wellness courses, health examination clinics, healthy lifestyle development sessions and injury prevention curriculums. Champions will be certified based on completing a four-day certification programme and joining in an annual conference. By this programme the country had reduced the costs by $3.5 million between 2005 and 2011.

16. **Cardinal rules**: Shell Global in US initiated 12 mandatory "Life-Saving" rules for all stakeholders and any break in these rules will lead to termination of employees and removal of contractor. These rule are: 1) Valid permits to work should be taken wherever required; 2) Gas tests should be conducted if required; 3) Using PPE and having isolation verification are required before starting with work; 4) Authorisation to enter confined spaces should be obtained prior entering these spaces; 5) Authorisation to override or disable safety critical equipment should be obtained; 6) Protection against falling while working at heights should be ensured; 7) Avoid walking under a hanging objects; 8) Prohibit smoking in undesignated areas; 9) Avoid driving or working under the effect of alcohol or drugs; 10) Avoid using phone or exceeding speed limits during driving vehicle; 11) Wearing seat belt; and 12) Following predetermined plan for journey management.

17. **Safety days**: In accordance to strength safety culture in the workplace, every year Shell celebrates the global safety days with all its stakeholders in order to share ideas and best practices. For instance, the theme of safety day in 2014 was "Take time for safety."

18. **Road safety**: The number of road deaths is different from on country to another. For example, this number in Turkey is ten times more than in France or Germany. Therefore, Shell implements a new travelling road technique as a mobile health clinic that provides vital health checks and safety information for drivers to notify them for any risk that they may face. It could notify for any surprise that may present in the way or for cars without headlights at night.

19. **Industrial theatre**: Shell was involved in a big energy project called the Pearl Gas to Liquid plant in Qatar. This project is an industrial theatre to present a dramatic exercise in order to deliver several home safety messages. One of the main messages is indicating the consequences of failing to use a safety harness when the worker is above the ground.

20. **Checks and balances**: Checks and balances is an important current emphasis at BP to deliver safe, reliable and efficient operations by steering inspection, checking and auditing. This assurance includes three levels. The first layer is safety that concerns on carrying out self-verification to approve the compatibility of operating management system, and to approve the robustness of barriers, and to permit them to take action if something is not met. The next layer is the Safety and Operational Risk organisation that conducts a specific risk-based assurance to indicate how the line is aligning with the requirements and sustaining and operating barriers. The third last layer is the audit that is conducted internally and in regular basis and externally by third party to ensure the compliance of the applicable regulations and standards.

Within this sort of best safety practices, ISHN (2014) described the importance of wearing PPE in workplaces. Based on that, employer should provide all workers with the required types of PPE.

Additionally, there should be a precise requirement procedure to select the appropriate candidate. A trained and qualified safety leadership has a strategic importance in directing the culture and behaviour. Thus, having a strong safety culture fosters all individuals to be aware of every single action they undertake. Furthermore, building a healthy workplace and worker by encouraging them to improve the extent of physical activity they undertake on a day-to-day basis is important. A part from that, contractor safety should be planned and managed systematically. Having an emergency preparedness, exposure assessment, maintenance, check and balance, inspection procedures and fire safety are critical best safety practices as well. Likewise, workplaces should build simple OHS goals and objectives and develop an effective management system to manage every operating decision made on a daily basis. Nevertheless, changes in the workplace should be addressed and investigated. Wellness programme, safety awareness and Safety days are some safety activities that stimulate workers to implement safety and prevent breaking rules and guidelines. In summary, these best practices are results of innovation and hard development efforts. They were tested, used in some developed and industrial countries, created notable records to the O&G industry and shared to help other countries.

2.10.3 Best Practices of Kenyon (2014) for the Oil and Gas Industry

As changes in the O&G industry are occurring continuously, a strong safety programme is required to adhere these changed properly. Kenyon (2014) has developed a new collection of best safety practices for the O&G industry. By implementing these best practices, Kenyon (2014) pointed that these practices are mandatory requirements for promoting safe operations and building and maintaining a strong safety programme the in O&G industry. Based on his point of view, the following best practices should be applied when the workplace is planning to make a change:

1. **Onboarding and ongoing training:** Effective onboarding and training programmes are very important to promote and maintain an appropriate safety culture. Primary evaluation for the internal processes is a vital step for instance to ensure that the right required criteria are met and to deflect attentions on the consistency of the onboarding for new employees. Once these aspects have been addressed, adapt the new standards and rules and assign them with current team members.

2. **Quality training:** This means that there is a regular replication and reminder for employees on the introduced ongoing training programmes in order to ensure that the worker are consistent and can remember. To prevent forgetting the material of the programmes, the workplace should have an enthusiastic team members who continuously look for new knowledge and advancement and the safety department should encourage and stimulate personnel improvement.

3. **Staying up-to-date on safety regulations:** As the O&G industry is a complicated, dangerous, workplace, adhering to regulations in this industry is essential. All individual should ensure a full regulatory compliance.

4. **Consistent communication:** Communication barriers arise in most workplaces. Greater clear communication is crucial in this industry to demonstrate the rapid changes in the guidelines and procedures. Regular safety meetings can simplify the understanding, adherence and accomplishment of tasks smoothly. Consistent on-site daily review sessions and incorporating consistent check-ins and refreshers are also ideal ways for communication that strengthen awareness and knowledge and decrease the risks.

From the above best practices, it is concluded that making any change in a workplace is not a single seldom activity instead it is and interrelated one that may affects many factors and components in the overall workplace.

2.10.4 Best Practices of Risktec (2016) for the Oil and Gas Industry

Risktec (2016) in UK, is an independent specialist risk management consulting and training company. It provides different services such as risk management consulting, resourcing, learning, inspection services, multi-year training and cultural support for companies and organisations in risky industries where the effect of loss is high like the O&G industry, chemical industry, nuclear industry and renewables industry. Moreover, it primarily tends to facilitate the sharing of good practice particularly in regions of the world where such legislation and regulations do not currently exist. In this regard, it provides an opportunity for the O&G industry and compnies to learn from other experience by sharing ten best practices based on concise and pragmatic HSE cases. Risktec (2016) developed these ten best practices to protect worker and the environment and assist this industry in controlling its assets, sustaining its competency and mitigating the risk of lost production which will contribute to the overall performance of this industry. These best practices are:

1. **Use what you have got, work out what you are missing:** Numerous HSE analyses reports and documentations are available in all workplaces. Ideally, workplaces should uses these results to build 'Gap Analysis' to solve the issues instead of redoing everything from scratch. Gap analysis assists in finding missed or inadequate matters more easily.

2. **Qualitative risk approaches can identify most improvements:** Experience based, qualitative risk assessment is a better approach to find the most possible risk reduction enhancements instead of quantifying the entire HSE risks and hazards.

3. **Record all HSE risks, that way nothing is overlooked:** Recording the identified and assessed all OHS isses, environmental problems, risk assessment reports, auditing results and occupational accidents statistics using a 'risk register' is valuable reference guide for any workplace. Encompassing all these data together contributes positively to the overall understanding of how to manage all visible and invisible risks precisely.

4. **But do not neglect major accident events:** Some tasks in the workplace are considered as most dangerous one like grit blasting. These risky tasks usually rely hardly on the competency of the worker supported by vigorous processes to evaluate and control the risk. Any mistake during these tasks result in massive fatalities and different environmental, costs and reputation losses. Thus, having a detailed and in-depth analysis and an appropriate level of verification and testing are vital requirement for implementing these risky tasks.

5. **Quantifying risk levels does help in some situations**: Quantitative risk assessment is an approach for reducing risk by considering risk based decision making but sometime using QRA solely is not adequate. However, it will be more powerful if it is adapted with cost-benefit analysis in order to make comparison between design phase's options or operations' changes.

6. **There is no easy formula for demonstrating risk is as low as reasonably practicable:** The as low as reasonably practicable level is reached when some factors like time, trouble and cost attached with additional risk reduction become unreasonably inconsistent to the advantage

gained before this level. It is a mathematical formula but practically it concerns on providing a balanced interpretation and achieving a defendable consensus on highlighted developments.

7. **Involve people, they know what is really going on:** Engaging the appropriate individuals to deal with the HSE case is crucial in gaining ownership of HSE risk management. This engagement includes take part in workshops, indicating where safety methods or measures do not produce the claimed benefits commenting on the accurateness of technical reports and contributing in training.

8. **Do not just analyse risk, understand how it is managed:** 'Bow-Tie' is a powerful and common risk assessment techniques. It is used to highlight the critical relation between risk controls (hardware or procedural) and the management system and the required workers' competency. Thus, it comforts in ensuring that risks are precisely controlled and managed by competent workers instead of just relying on the analysis.

9. **Live by the HSE case, don not stick it on the shelf:** Continuous communication and application of the HSE case, HSE will be consequently improved and maintained.

10. **Risk management requires action not words:** In reality, addressing any issues requires actions to be undertaken not just talking. In other words, any case can create a wide range of recommendations that should be carried out and managed accurately.

In general, these ten best practices depend first on a well-understanding for the current situation of the workplace and then applying some investigations to reduce and control risks and hazards.

2.10.5 Best Practices for Paraventi (2014) for the Oil and Gas Industry

As well as, some best practices were created to be applied in the O&G industry by considering the causes of accidents in this industry. Paraventi (2014) identified several best practices for top hazards in the O&G industry in the article 'How to reduce the high fatality rate in O&G. These best practices are:

1. **Highway motor vehicle crashes**: The top cause of death in the O&G industry is highway vehicle crashes. NIOSH introduced a number of rules that ensure that the drivers of vehicle have valid licenses; apply fatigue management into safety programs; offer fleet vehicles that protect

occupants during a crash; provide regular vision screening and general physicals examination for employees; and avoid the driver on job to exceed the maximum driving hours.

2. **Struck-by/caught-in/caught-between**: It is the second cause of death in the O&G industry. Three of every five fatalities in the O&G industry are resulted from struck-by/caught-in/caught-between hazards or machine. It originates from numerous sources like moving vehicles or equipment, falling object or equipment and high-pressure lines. Based on these sources, Occupational Safety and Health Administration (OSHA) implements several recommendations like conducting frequent inspections of all hoisting lines; compiling with the required field lubrication from the wire rope producer; employing a slipping and cut-off preventive maintenance programme for hoisting lines; and urgently eliminating damaged lifting lines from usage.

3. **Fires and explosions**: It is the third principal fatal causes of accidents in the O&G industry. Flammable gases can be generated from trucks, wells, production equipment or surface equipment like shale shakers and tanks. OSHA has recommended that Job Hazard Analyses should be executed before starting with handling tasks to notify about any potential hazards. After that, a hot work permitting programme should be started to evaluate and highlight the level of flammable vapours in the atmosphere. Finally, flame-resistant clothing (FRC) should be wore by all employees who may be first influenced by fire hazards.

4. **Falls**: Falls from higher level to lower level record six percent of the entire fatalities in the O&G industry. To overcome this accident, safety net systems, Guardrail systems or Personal Fall Arrest Systems (PFAS) should be adapted to protect employees who involved with tasks above the ground. Also, tasks and locations that required employees to be above the ground should be evaluated. Moreover, training on the appropriate use of PFAS should be provided for all workers. Further, a mandatory rule that forces those employees to use all fall protection equipment should be incorporated.

5. **Confined spaces**: Confined spaces in the O&G industry like storing tanks, reserve pits, mud pits, and other excavated areas, and storing containers sand can lead to major atmospheric and chemical hazards. Thus, these hazards must require obtaining permit for confined spaces, evaluation on the confined spaces before entering and a continuous observation on these spaces.

6. **High-pressure hazards**: Compressed gases or high-pressure lines can lead to vital risks. NIOSH has mitigated these risks by offering a ''checklist 4'' including OSHA regulations underpinning the General Industry standard(29 CFR 1910.101) that applies to perform, store and use compressed gases in portable tanks or cylinders.

7. **Hazardous energy**: Exposure to unrestrained electrical, hydraulic, mechanical, or other unsafe energy sources is another risk. It can be reduced by OSHA's Lockout/Tagout fact ''sheet 5'' that concerns on providing the required practices and actions to disable equipment or machinery to stop the release of hazardous energy. The OSHA standard for the Control of Hazardous Energy (Lockout/Tagout) (29 CFR 1910.147) for general industry also offers several useful measures to control various forms of hazardous energy.

8. **Musculoskeletal disorders**: Ergonomic accidents are resulted from pushing and pulling heavy loads, lifting heavy items, reaching overhead, bending, executing the same or repetitive tasks and working in unsuitable body postures. This type of accident can be categorised by pre-task planning, use of the correct tools, appropriate placement of materials and educating workers regarding the risk.

By reviewing these applications of best practices in the O&G industry, a wide range of aspects and factors in the workplace of this industry are considered as critical in regards to accidents in general and human error accidents in specific. Some of these factors are related to the workers themselves, management role, their decisions, safety leadership, workplace conditions and others. However, the above applications of best practices focus on some factors that have a high priority in order to reduce the probability of accidents in this industry. For instance, workers in the O&G industry should wear PPE and should pay attention to their wellness and health in relation to their job requirement in this industry. Nevertheless, training plays a key role in these applications of best practices. Training courses should be provided taking into consideration the quality of these courses and they should be updated regularly. Moreover, these best practices indicate the importance of communication between all levels and it should be showed clearly in the role of safety manager and safety leadership.

Apart from that, hazards and risks in the O&G industry should be identified, managed, controlled and monitored regularly. From the above applications of best practices, different types of analyses, assessments and techniques are developed to do that. Further, response strategy, emergency plan, exposure assessment and fire safety plan are example of precaution activities that most of these applications of best practices have indicated its importance. These examples should be developed, clearly written and placed for any future unplanned accidents. Aligning with that, introducing any change in this workplace is one of the most critical activities. It should be planned accurately and communicated to worker in addition to train workers on it. On top of that, safety culture is utmost important factor in these applications of best practices. It includes the working rules and internal control in the workplace and the behaviour and attitudes of workers. This culture should give safety a top priority in order to build a high level of safety awareness among workers. Finally, some of these best practices showed that any safety work need a serious action not just words. A summary for these applications of best practices is provided in Table 2.4.

Table 2.4: Examples of Best Practices in the Oil and Gas Industry

Factors	HSE (2006)	ISHN (2014)	Kenyon (2014)	Risktec (2013)	Paraventi (2014)
Management role		✓			
Leadership role	✓				
Safety culture	✓	✓			
Performance management/ management systems	✓	✓			
Internal controls/ safety regulations/ safety rules/	✓	✓	✓		
Workplace specifications/ workplace hazards				✓	✓
Organisational structures	✓				
PPE		✓			
Safety training		✓	✓		
Emergency preparedness		✓			
Fire safety		✓			✓
Changes management		✓			
Maintenance		✓			
Safety awareness		✓			
Risk assessment/ risk analysis/ risk management		✓		✓	
Communication			✓		
Lessons learned				✓	
Employee involvement				✓	
Implementation of HSE				✓	
Musculoskeletal disorders					✓

Based on these best safety practices, several concepts are covered by most of these best practices and there is a high consensus on it. Providing all employees with adequate training courses, building an effective safety culture, providing risk analysis in workplaces, building an open communication, sharing knowledge and best practices and establishing an emergency plan are highly expressed within these best safety practices. Different tools and solution are provided to achieve these practices effectively. On top of that, most of these best safety practices indicated that both managers and workers should be involved in safety matters. In other words, active role of top management and safety leadership plays a key role in increasing safety performance in workplaces. Nevertheless, improving the safety skill and experience of worker is important by appropriate safety leadership, visible commitment and regular training. Providing employees with appropriate PPE is an important precaution step. However, workplace should not only setting out safety standards, rules, goals, objectives and values but also complying with international safety standards and regulations. Additionally, regular inspections and risk assessment controls are important for improving safety performance.

On the other hand, some best practices pointed out several unique best safety practices. These different practices can be referred to the different natures of workplaces and different purposes of building these best practices. Building fitness campaign, developing safety awarding, controlling the financial losses and sharing price, providing contractor safety outlook and focusing on fatigue management are new aspects that are discussed in these practices. However, these are some practices that are mentioned with low level of consensus. Performing regular auditing, recording all accidents, installing special safety programs based on the undertaken activities, providing worksite evaluation and ensuring full understanding of safety regulations are some examples. This low level of consensus does not means that these best practices are not effective rather it means that these aspects may be new practices, individual exploratory result or patented. The main similarities and differences between these best safety practices are provided in Table 2.5

Table 2.5: Similarities and Differences between Best Practices

Similarities	Differences
• Providing all employees with adequate training courses. • Building an effective safety culture. • Active role of top management and safety leadership. • Providing risk analysis in workplaces. • Building an open communication. • Complying all activities with safety rules and standards. • Setting out safety standards, rules, goals, objectives and values precisely. • Sharing knowledge and best practices. • Concentrating on employees' safety skill and experience even before recruiting them. • Establishing an emergency plan. • Improving and monitoring safety performance. • Providing regular inspections. • Providing employees with PPE.	• Performing regular auditing. • Controlling the financial losses and sharing price. • Fitness campaign. • Providing contractor safety outlook. • Safety awarding. • Recording all accidents. • Focusing on fatigue management. • Installing special safety programs based on the undertaken activities. • Providing worksite evaluation. • Using proper tools. • Ensuring full understanding of safety regulations.

As the aim of this research is to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan and after addressing all these issues, it is important to turn the discussion to safety strategy for the O&G industry in Bahrain. The next section describes that.

2.11 Safety Strategy for the Oil and Gas Industry in Bahrain

Regarding the current market' setting, Avnet (2015) indicated that complicated relations between organisational factors and safety practices and results have presented in the workplace. Further, he stated that it is generally agreed that safety cannot be adequately addressed using technical analysis solely; instead, a strategy that models the organisational issues in accordance to safety matters is needed at present. In fact, strategy is an issue that touches the long-term future of any workplace. Thus, it a critical matter for all managers and employees in order to understand the strategic direction of their workplaces (Johnson, Whittington, Scholes, Angwin & RegnŽr, 2013). A detail discussion about a strategy is provided in the next sub-sections.

2.11.1 Strategy Definition

Nickols (2011) stated that the term strategy is a Greek word "strategia" means "generalship". In general, the notion of strategy was first used in the military and then it has been adopted in business (Nickols, 2011; Saylor Academy, 2014; Dobson, Starkey and Richards, 2009). Based on that, although a wide range of definitions of strategy was presented in literature, the root definition of this term is referred to military strategy that encompasses the development of war plan, the organisation of individual campaigns and, within these, the arrangement of individual engagements with the enemy. Earlier authors like Steiner (1979) had summarised the meaning of strategy in the business world in six points as follows:

1. Strategy is a responsibility of top management to do an important thing for the workplace.
2. Strategy represent the directional decisions.
3. Strategy contains essential and actions to understand these directions.
4. Strategy is the answer for what should the workplace be involved in?
5. Strategy is the question of what the conclusions are and how to reach them?

In the same vein, Mintzberg (1994) and Nickols (2011) found that any strategy is a combination of four terms as plan, pattern, position and perspective. First, it is a plan that describes how to transit from one area to another. Second, it is a pattern in actions over a period. Third, it is a position that reveals decisions to sell particular products or services in a specific market. Finally, it is a perception of vision and direction. Further, Porter (1996) has defined a strategy as achieving a competitive advantage with the same industry by delivering customers with an exclusive product or service having a strong knowledge of how to position yourself exclusively. Hence, it focuses on matching a workplace's capabilities with its external environment. In contrast, Hamel (2002) indicated that the best strategy focuses on achieving a fundamental change and developing a novel future vision in order to be a leader in the industry rather than a follower (Brinkschröder, 2014; Lorange, 1998). As a mean of illustration, it is important that a strategy adapts to the changes and become more dynamic and gets consecutively revised and reviewed.

Similarly, Johnson et al. (2013) and Dobson et al. (2009) concluded that strategy is a way of saying how a workplace creates a unique value to attract the custom in the market in order to assure its long-term survival in a competitive environment. From another point of view, Brinkschröder (2014) found that a strategy is closely connected to the growth of knowledge base of an organisation and he defined a strategy in general as the knowledge of the organisation evolves and allows new insight. However, Nickols (2011) stated that as strategy clarifies obtaining the end, therefore, it is a pathway with clear guidance to undertake actions. The statement of a strategy covers three main themes (Johnson et al., 2013). First, the fundamental goals that the workplace seek that are related to vision, mission and objectives. Second, the scope and boundaries of the activities in the workplace. Third, the positive outcomes it has to deliver. These all themes will assist in sharing the same understanding of what we are trying to achieve, why, and how we intend to achieve it (Health and Safety Commission HSC, 2004).

On the other hand, Dobson et al. (2009) explained that strategy could be viewed from two different perspectives. The first one is the top-down approach that equates strategy with planning. This means that information is gathered, sifted, analysed and forecasted and based on results senior managers have to decide the best course for the workplace. This approach fits a stable and predictable environment. While the second one is a less structured perspective that addresses the process of management. This is reached by putting in place a management system that will simplify the capability of the workplace to respond to an unknowable, unpredictable and not amenable environment. This flexible approach fits a fast changing and essentially unpredictable.

Apart from that, Johnson et al. (2013) described three levels of strategies that should be integrated and aligned together in any workplace. These strategies are corporate-level strategy, business-level strategy and operational strategies. The corporate level strategy tend to describe the main scope of a workplace by focusing on the delivered value added. This covers geographical scope, variety of products or services, acquirement of new businesses, and how to allocate the resources among various available elements in the workplace. While business-level strategy describes how to compete in the markets. It covers appropriate scale, research and development, innovation and response to the pressure of competitors. Finally, operational strategies describe how various features and components of a workplace like people, resources and processes drive a successful achievement for the other two higher levels strategies. It depends widely on decisions and activities of operational level.

Based on the above discussion, strategy formulation is an essential activity in the workplace. Saylor Academy (2014) identified six steps for an effective formulation. Those steps are:

1. Defining the workplace to identify the main customers.

2. Defining the strategic mission that offers a long-range perspective of what the workplace strives for going forward.

3. Defining the strategic objectives to identify the performance targets needed.

4. Defining the competitive strategy to determine where it fits into the market.

5. Implementing strategies to put the overall strategy into place appropriately.

6. Evaluating progress to ensure the ongoing success.

As strategy has been discussed in the previous lines, it is important to move the discussion to safety strategy. The next section concerns about that.

2.11.2 Safety Strategy

In general, there is no best strategy and even if a specific strategy delivers a successful outcome, it will not remain as a best without the need of further alterations during a changing world and market. It should be changed radically to remain effective and relevant (HSE, 2010; Dobson et al., 2009). In the same line, even if there is an effective strategy for one workplace, its contents and guidelines may be unreliable for another workplace in another geographical location (Achaw and Boateng, 2012). As a strategy is an important and critical issue in every workplaces, it is also important in large process industries like the O&G industry and especially in OHS perspective (Westhuyzen, 2015; Clark et al., 2013).

However, as the rate of occupational accidents in this industry is considerable, paying attention to industrial safety is also a critical issue that must be considered. Industrial safety is an essential safeguard for the O&G industry for all stakeholders like workers, supervisors, and managers, professionals, contractors and partners in order to understand the current OHS issues, hazards and risks, the required controls and measures and the required safety standards and compliance procedure (Moraru, 2014). Industrial safety fosters a number of capabilities in the workplace that assists in acquiring the cornerstone of preventing accidents and valuing the conceptual importance of risk prevention. The ability to convey critical analysis, develop, manage and control the preventive action plan, promote and share a preventive culture and perform risk analysis and support are some examples of these capabilities (Díaz-de-Mera-Sanchez et al., 2015). Thus, safety legislation and regulations, strategies play a key role in developing an appropriate action plan for enhancing the industrial safety strategy. Aligning with importance of strategy and industrial safety in the O&G industry, enhancing the industrial safety strategy should not be overlooked. This strategy should indicate how the health and safety of this industry and the overall industry should be regulated, and it should cover what each employee should do to improve the health and safety performance and many other issues (HSE, 2014). In addition, it should point out the responsibility of safety top management and leaders for the delivery of high standards of health and safety in this industry in order to ensure that risks are consistently well-managed across the industry. The principal major hazards that could cause occupational accidents are also well-identified in this strategy with the required precautions steps.

Regarding the importance of this strategy in the O&G industry, Saylor Academy (2014) argued that this strategy is of utmost importance to enable OHS at work to contribute positively to the workplace in term of:

- Employment and productivity: by ensuring the protection of workers and maintaining safe working conditions.
- Education: by starting with building an appropriate knowledge of how to manage risks from an early age.
- Health and rehabilitation: by focusing on the nation's health and wellbeing of workers and addressing health inequities.

In this stage, it is important to consider Bahrain in this discussion. The next sub-section explains that.

2.11.3 Safety Strategy in Bahrain

Based on the discussion in section 2.9, safety strategy in Bahrain still needs more steps to be built because there is no certain strategy for the O&G industry, the available legislations are too old and the enforcements are not too strong. In general, building an action plan for enhancing the safety strategy for the O&G industry in Bahrain will mark a significant change to the way of approaching regulations of the industry and how to drive improvement in OHS regulations and standards. Building this strategy is an important issue especially as still how these workplaces think about safety and how safety can be reached are both questionable (Besnard & Hollnagel, 2012). On top of that, this importance has increased because of the result of reviewing the current OHS framework of Bahrain by NEBOSH and Matooq and Suliman (2013b) indicated that this framework requires more standardisation, consistency and fairness and as it was dated to more than 30 years ago.

As well as, this strategy is a prerequisite especially during the lack of specific OHS regulations for the O&G industry setting in Bahrain. Thus, it is important to begin working on establishing a new strategy that underpin the new direction of improvement in this industry. In fact, enhancing the industrial strategy to reduce human error in Bahrain is no longer can be ignored. This strategy will set out a clear vision for the long-term future of the O&G industry in Bahrain by highlighting a clear path of the opportunities for the industry and the priorities for future actions by industry, government and other stakeholders. It is also vitally important to recognise the long-term importance of this strategy in the O&G industry. This guidance will focus on the strategic priorities identified and subsequent activities in term of reducing human error to assist the industry to grow. The overall theme of this strategy should be reducing the accident rate through human errors and other organisational factors in a workplace. This will deliver concrete benefits to the industry and the economy. Actually, it will have a significant impact on the overall OHS level, productivity, costs and many other contributions. In addition, this strategy will assist in developing the capability to remain a driver of wider economic activity and growth in Bahrain.

Several vital aspects should be highlighted in this strategy. This safety strategy should have a clear vision, mission, priorities or outcomes and action areas. It should map out the strategic direction for OHS in a workplace within a specific period. Although this strategy will be highly driven by the workplace nature and requirements, local and international legislations, regulations and standards, and market and economic requirements, it should provide the plan for how to maintain OHS compliance internally and externally, build a positive and maintainable safety culture and develop an effective and consistent safety leadership. Addressing safety leadership matters will develop to support the workplace in its endeavours to stimulate positive safety behaviours and to monitor the OHS performance. This strategy also should indicate that workplaces should be fostered by leaders who clearly understand their roles and accept ownership and full accountability for OHS problems. This strategy also should be designed to build the progress of a workplace, draw the direction and pathway, bring all workers, managers, partnerships, contractor, service providers and stakeholders together, keep pace with different changes, improve OHS performance, deflect the attention to aspects that will contribute positively and encourage more OHS improvement and investment.

However, the success of this strategy requires competent and well-trained people at every level. This will ensure the fulfilment of OHS responsibilities and will ensure a continual improvement of OHS performance. Furthermore, this strategy should concern on ensuring that all interested parties play their part to maintain a proactive and robust OHS level and reduce the potential of risk or accidents. To deliver a safer and healthier working conditions and workplace, this strategy should pointed that there should be a strong communication and good OHS practices in every aspect of daily activities. In this regard, all interested parties should be fully engaged and participated at all levels of the organisation taking advantage from the advanced ICT technologies. Based on that, risks should be managed and controlled frequently to sustain an acceptable level and this requires all managers and safety leadership to have a deep understanding on these risk and hazards in order to provide the necessary measures.

After discussing all these points, it is important to have a quick review on the main body of the literature as a whole. The next section provides that.

2.12 Chapter Summary

As globalisation is the most critical challenge for most industries, safety should be managed properly and effectively to reduce the accidents rate. Additionally, understanding OHS matters and ensuring an adequate level of OHS performance are utmost important for workplaces. OHS is a science that anticipates, identifies, evaluates and controls hazards in a workplace that will lead to high safety performance during this rapid globalisation of trade. An appropriate OHS management system performance will increase the performance of staff and the availability of work by reciprocal and interactive relationships between the work environment and the workers. Several leading OHS bodies like KOSHA and ILO were developed. However, still figures revealed that there is an increase in occupational accidents around the world (Hämäläinen et al., 2017). Many researches in safety and human error aspects have confirmed that a substantial proportion of accidents were resulted from human error. Thus, placing concerns on human factors can reduce these accidents. Examples of human factors are like poor role of top management, poor safety leadership, poor safety culture, poor design of workplace, defective machinery, ineffective accidents reporting system, improper technology, stress, low level of education, improper training and lack of multi-professional approach.

The O&G industry is the backbone of the economy in Bahrain. Bahrain was the first country to discover oil regionally and in the Middle East. The O&G industry in Bahrain confronts with numerous challenges that can be classified as challenges as developing country, challenges as a petroleum country and challenges of the current market conditions. However, OHS framework in

Bahrain needs a strong improvement to increase transparency, consistency and fairness. Moreover, researchers and statistics indicated that most of accidents in the O&G industry in Bahrain were caused by human error. Therefore, an industrial safety strategy is becoming a need for this industry in Bahrain.

Therefor, this chapter provided a comprehensive literature review and syntheses regarding the objectives of the current research. Discussion of OHS was presented by describing safety, OHS related issues, the required OHS management system and OHS leading bodies. Then, a discussion of accidents and the major accidents in the world was provided with a deep concentration on the root cause of accident. Human error was widely discussed also. After that, a review on O&G in industry in general was created followed by pointing the main best practices in this industry in term of OHS concept. Next, a detailed discussion on the O&G industry in Bahrain was presented by identifying the current circumstances of this industry and the related OHS regulations and challenges. Finally, an explanation of strategy concept was provided to indicate the importance of this strategy in the O&G industry in Bahrain context.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

In order to achieve the aim and objectives of this research, the third chapter aims to illustrate and explain the adapted research methodology. This chapter provides a wider understanding about the philosophical stand of this research along with some justifications. Additionally, different types of research strategies have been identified by different authors, the adapted research strategy is discussed and justified. Then, the adapted research choice and time horizon are illustrated. Further, the applied data collection and analysis methods and techniques are presented and described. The justification for these methods and techniques is included as well. After that, a detailed discussion of validity and reliability used in this research is presented. Moreover, the ethical consideration of this research is discussed.

3.2 Research Methodological Framework

Research methodology expresses the path that a researcher should follow to undertake a research by indicating the philosophical assumptions and underpinnings of a research and the consequences of the used method or methods (Saunders & Rojon, 2014; Saunders et al., 2012; Easterby-Smith, Thorpe & Jackson, 2012). Research methodology describes precisely the required processes aligned with the required methods to conduct a research, while a method specifies the technique to collect data and/or to analyse the collected data (Collis and Hussey, 2009). Different scholars have proposed different types of methodological framework. This research adapts a framework called the 'Research Onion' established by Saunders et al. (2012). Research onion is one of main frameworks for research methodology with its six layers which are research philosophy, research approach, research strategy, research choice, time horizon, and technique and procedure. These layers are shown in Table 3.1 and Figure 3.1.

Table 3.1: Research Onion Breakdown (Source: Saunders & Lewis, 2016)

Layer	**Approaches**
Research Philosophy	Positivism, Interpretivism (or Phenomenology), Realism.
Research Approach	Deductive, Inductive, Abductive.
Research Strategy	Experiment, Survey, Case Study, Ground Theory, Ethnography, Action Research.
Time Horizons	Cross Sectional, Longitudinal.
Data Collection Methods	Sampling, Secondary Data, Observation, Interviews, Questionnaires.
Research Choice	Mono-Method, Multi-Method, Mixed Method.

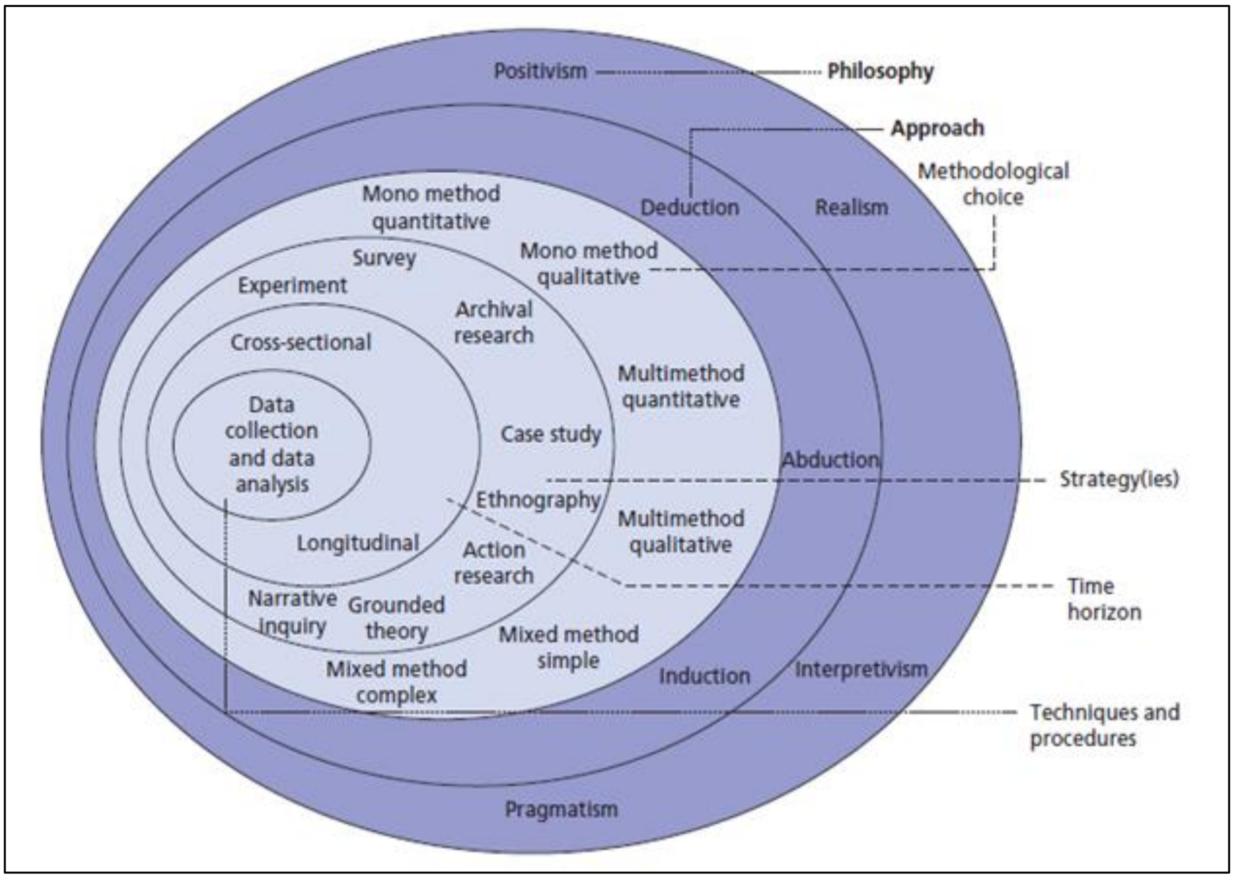

Figure 3.1: Research Onion (Source: Saunders & Lewis, 2016)

Research onion provides a clear guideline to precisely adapt the appropriate methodology for a research, starting from the first layer which is the research philosophical stand to the last layer which is the data collection and analysis methods. As the current research is a descriptive one that aims to show an accurate profile and a clear understanding of human error accidents in the O&G industry in Bahrain, research onion is adapted. Research onion is applied particularly in this research because it has more detailed structure that provides a broader insight to address human errors accidents aligning with evaluating the challenges regarding human errors specific accidents in this industry. Also it is adapted because it provides a detailed understanding on the current OHS legislation, regulations and implementation in the O&G industry in Bahrain.

3.3 Research Philosophy

Research philosophy describes the development of knowledge and the nature of that knowledge, and the philosophy to be applied includes significant assumptions regarding how we interpret the world (Saunders et al., 2012). Research philosophy actually assists in expressing and clarifying the research designs, indicating the most appropriate design, and identifying and even creating research designs that may be outside researcher's prior experience (Easterby-Smith et al., 2012). Further, Collins & Hussey (2003) described research philosophy as a set of beliefs, philosophies and assumptions from a researcher's point of view regarding the nature of knowledge and different aspects reveal in the world. When conducting any research, there is no definite rule that specifies which philosophy to choice because the research philosophy reveals researcher thinking about the development of knowledge (Yin, 2009; Collis and Hussey, 2009) as it mainly relies on the research aim, objectives, questions and data collection methods. Based on Collis and Hussey (2013), the philosophical assumptions are categorised into three categories which are the ontological assumption, epistemological assumption and axiological assumption as shown in Table 3.2.

Table 3.2: Philosophical Assumptions and Philosophies (Source: Collis & Hussey, 2013)

Philosophical assumption	Positivism	Interpretivism
Ontological assumption (the nature of reality)	Reality is objective and singular, separate from the research	Reality is subjective and multiple, as seen by the participants
Epistemological assumption (what constitutes valid knowledge)	Researcher is independent of that being researched	Researcher interacts with that being researched
Axiological assumption (the role of values)	Research is value free and unbiased	Researcher acknowledges that research is value-leaden and biases are present

However, Saunders et al. (2012), Collis and Hussey (2013) and Easterby-Smith et al. (2012) have confirmed that there are two main research philosophies that are related to each philosophical assumption category. Positivism and interpretivism are the two philosophies, and these are described in the next section.

3.3.1 Ontology

The first research philosophical assumption is Ontology. It concerns with the philosophical assumption regarding the nature of reality (Saunders et al., 2012; and Easterby-Smith et al., 2012). It emphasises on the reality of, and association between, various aspects of social actors, cultural norms and social structures (Jupp, 2006). According to Saunders et al. (2012), the ontology continuum is represented by objectivism and subjectivism. They found that the objectivism believes that social entities present in the real world external to social actors while the subjectivism assumes that social phenomena are resulted from the perceptions and activities of social actors. Moreover, Collis and Hussey (2009) have identified that objectivism mostly views the reality as an objective and a singular which is not related to the researcher whereas subjectivism mostly views the reality as a subjective and multiple, as seen by participants.

3.3.2 Epistemology

The second research philosophical assumption is Epistemology. It concerns on the accepted valid knowledge (Collis and Hussey, 2009). In other expression, it focuses on theory of knowledge (nature and definition), the methods of this knowledge, the validity of this knowledge (certainty, justification and evidence) and how to obtain this knowledge (Sutrisna, 2009). Additionally, Creswell, Hanson, Clark Plano & Morales (2007) pointed out that epistemology is the relationship between the researcher and the participants or that being researched. Sexton (2008) found that epistemological assumptions are general collections of assumptions regarding how a researcher obtains and accepts knowledge (reality) regarding the surrounding world. Various scholars have categorised epistemology into different categories but the meanings remain the same. For instance, Saunders et al. (2012) and Collis and Hussey (2009) termed it as positivism and interpretivism whereas Easterby-Smith et al. (2012) called it as positivism and social constructivism.

According to Easterby-Smith et al. (2012), positivism assumes that the entire social world presents externally and its properties should be assessed taking advantage from objective factors instead of being assessed subjectively by sensation, reflection or intuition. Based on that, the positivist assumes that only phenomena that can be observable and measurable can be validly accepted as knowledge; thereby, the researcher in this situation is independent from that being researched (Collis and Hussey, 2009). From the social scientist point of view, the assumption of positivism is highly applied in the methods in natural sciences to the social sciences (Bryman and Bell, 2011; Denscombe, 2010). While the assumption of interpretivism or social-constructivism concerns on brining the researcher and what is being researched closed to each other (Collis and Hussey, 2009). Based on that, the phenomena is measured subjectively by individuals rather than by objective methods (Easterby-Smith et al., 2012). Moreover, Easterby-Smith et al. (2012) provided a summary for the differences between positivism and the interpretivism/social-constructionism as it is shown in Table 3.3.

Table 3.3: Contrasting Implications of Positivism and Social Constructionism (Source: Easterby-Smith et al., 2012)

	Positivism	Social Constructionism
The observer	Must be independent	Is part of what is being observed
Human interests	Should be irrelevant	Are the main driver of the science
Explanations	Must demonstrate causality	Aim to increase the general understanding of the situation
Research progress through	Hypotheses and deduction	Gathering rich data from which ideas are induced
Concepts	Need to be defined so that they can be measured	Should incorporate stakeholder perspectives
Units of analysis	Should be reduced to the simplest terms	May include the complexity of the 'whole' situation
Generalization through	Statistical probability	Theoretical abstraction
Sampling requires	Large numbers selected randomly	Small numbers of cases chosen for specific reasons

3.3.3 Axiology

The third and last philosophical assumption is axiology. It concerns on the role of value (Saunders et al., 2012). Collis and Hussey (2009) found that the axiology continuum is represented by value-free and value-laden. They assumed that the value-free assumptions are used mostly with positivism research which determines that the objects of a research will remain the same and will not change or be influenced by any activities of the research. In contrast, they assumed that the value laden assumptions are linked mostly to interpretivism research. In other words, the positivist research is value-free from any impacts from the society, ethics, and politics and unbiased and it is independent from what is being researched as well. While the interpretivist is value laden that assumes that the researcher is part of which is being researched. Moreover, Collis and Hussey (2013) pointed out that the value-free are mostly used in natural science studies and rarely used in the social sciences because social sciences emphasise on individuals in term of their activities, interactions, attitude and behaviour.

3.3.4 Philosophical Positioning of the Research

The aim of the current research is to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan. Based on that, the process of understanding the definition of human error, the setting of human error accidents in the O&G industry in Bahrain, the main challenges related to this type of accidents and the best practices related to this context involves the perceptions of people. The expertise and experience of those people play key role in interpreting the reality of these accidents. Obtaining participant's subjective analysis and subjective conclusions clarify the importance of applying a social constructed research in which the reality is subjective and multiple as seen by the participants. Thus, this requires the researcher to be involved in the research in order to provide his value to the knowledge.

Accordingly, through the ontological assumption, interpretivism is followed in this research as it expresses the world by workers' actions and interactions in both the managerial and operational levels which in turn it assists in treating human error accidents in the O&G industry in Bahrain. While through the epistemological assumption, the interpretivism philosophy is adhered in the current research. It expresses how a researcher recognises various assumptions and the knowledge reality that should be accepted regarding human error and the current OHS legislation, regulations and implementation in this industry in Bahrain. Further, this philosophy provides meanings behind the managerial and operational levels' actions and opinions. This philosophy also seeks to provide a description to human errors in this industry and it consequently evaluates the main related challenges in order to enhance the industrial safety strategy.

On the other hand, through the axiological assumption, the value laden is applied in the current research. Judgements on value are the core of this philosophy (Collis & Hussey, 2013; Saunders et al., 2012). As value-laden means beliefs and experience (Easterby-Smith, 2002), it is applied in this research to present the beliefs and experience of the managerial level and operational level in order to achieve the current objectives. For example, as the managerial level is a main social actor in this industry in Bahrain, the personal interactions during the semi-structured interviews with this level play key role in gaining a broader insights and perceptions regarding their points of view on human error accidents and current OHS framework.

As the research philosophy was described in this section, the next section explains the second layer of the research onion which is the research approach.

3.4 Research Approach

Research approach is the way in which theory is developed. The research aim and objectives are critical factors that affect and determine the selection of the research approach. Research approach has three different types which are the deductive, inductive and abductive approaches (Saunders et al., 2012).The deductive approach is simply a theory testing approach. It begins first with developing a theory and hypothesis (or hypotheses) and ends with testing the hypothesis using the designed research strategy. Literature review plays a key role in deductive approach in order to build the conceptual framework and to set out the hypotheses. This hypothesis should be tested by gathering data to affirm it or reject it. In comparison, the inductive approach is simply a theory building approach. It starts with collecting data and ends with creating a theory that rely heavily on the results of analysing the gathered data (Saunders et al., 2016). It is more useful in understanding social or human problems from multiple standpoints and angles (Yin, 2009). From Collis and Hussey (2009) point of view, the deductive approach goes from the general to the particular, while the inductive goes from the particular to the general. The deductive approach is highly applied with positivism assumption but the inductive approach is highly applied with interpretivism assumption (Saunders et al., 2016). On the other hand, the abductive approach is an integrated approach that combines the two approaches together. This combination allows the researcher to utilise from multiple research strategies and methods to get a logical and practical results to the research problem (Dawood and Underwood, 2010).

Selecting the most appropriate research approach depends on the philosophical stance subjective, interpretivist and value-laden. The adapted philosophical stance and the aim and objectives of this research direct the researcher to apply the abductive approach. Through this approach, this research will take advantages from the two approaches and any limitation in one approach will be balanced by the other one. This approach gives the researcher more flexibility in using the inductive and deductive approaches based on the requirements of the research. Accordingly, the context of human error accidents and particularly in the O&G industry in Bahrain will be explored deeply, the challenges related to these accidents will be identified and evaluated intensely and the best safety practices in this industry will be discussed clearly. It is adapted to have a close understanding of human error accidents context. It also assists in gaining a valuable understanding of the meanings the workers attach to human error accidents in the O&G industry in Bahrain in order to have a holistic picture on this phenomena which will assist in enhancing the industrial safety strategy. Then, the researcher will gain the critical required knowledge by collecting data from social actors in order to enhance the industrial safety strategy. Enhancing this strategy will require validation and adjustment that require expert input to test it. Therefore, solely depending on one approach is not adequate for the current research. According to Saunders et al. (2009), the researcher can use both the empirical and non-empirical data for answering the research questions. Thus, interviews, questionnaire surveys, governmental policy documents on the O&G industry, industry reports, available journal articles, conference papers and text books can be used appropriately using the abductive approach that is suitable for stage of research.

3.5 Research Strategy

Research strategy is the third layers in research onion. Saunders et al. (2012) pointed that research strategy clarifies how the researcher intends to carry out the research to address the research objectives and questions. He indicated also that there is no superior strategy or inferior to any other and they are not mutually exclusive.

3.5.1 Types of Research Strategy

Different types of research strategies and various classifications are available. Based on Saunders et al. (2012), there are seven types of research strategy which are experiment, survey, action research, case study, grounded theory, archival research and ethnography. Whereas, based on Yin's (2009) classification, there are five types of research strategy which are experiment, survey, case study, archival analysis and history. Therefore, the research could be a mixture of a number of strategies. However, different methods can be used to justify the applied research strategy. The first method is by considering the adapted research philosophical assumptions of the research (Sexton, 2008). Figure 3.2 shows the relation between the types of research strategy and the philosophical assumptions.

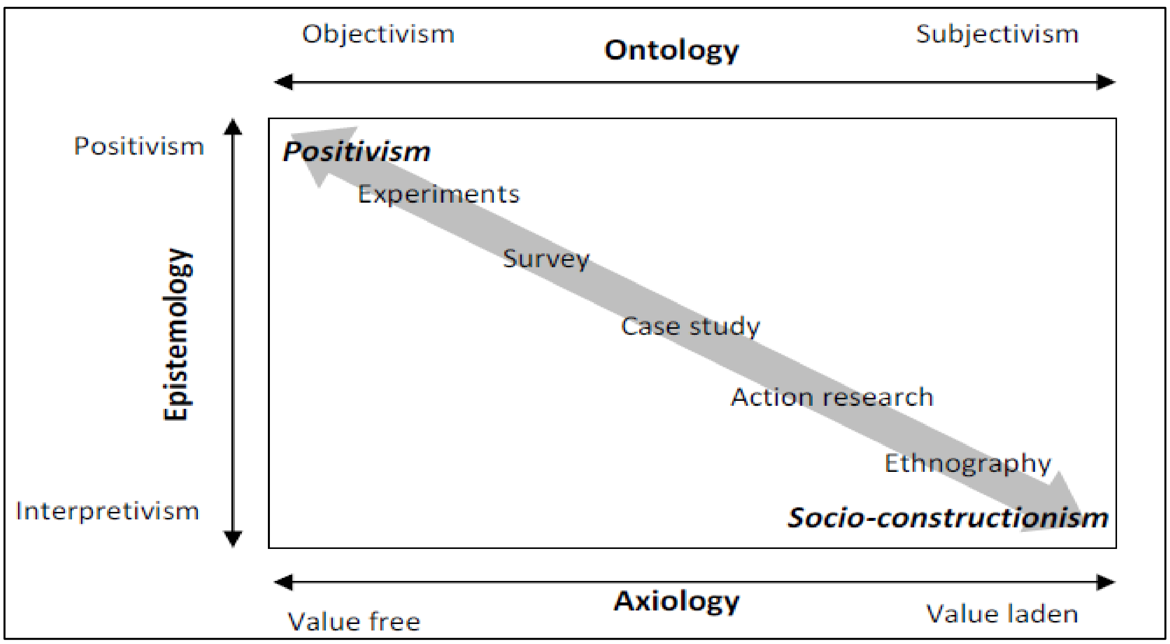

Figure 3.2: Research Strategy Continuum in Relation to Research Philosophical Assumptions (Source: Sexton, 2008)

However, Yin's (2009) has proposed another method that depends on three criteria which are the type of research questions, the degree of control a researcher has over actual behavioural events and the extent of focus on the contemporary events rather than the historical events. However, Yin's (2009) pointed out that classifying the type of questions being asked is very important. Questions can be in different schemes like 'who', 'what', 'where', 'how' and 'why' questions. The relation between the question scheme and the research strategy is outlined in Table 3.4. The adapted research strategy aligning with it justifications are provided in the next section.

Table 3.4: Research Strategies regarding the form of Research Questions, Behavioural Events Control and Contemporary Events (Source: Yin, 2009)

Strategy	Form of Research Question	Requires control of Behavioural Events?	Focus on Contemporary Events?
Experiment	How, Why?	Yes	Yes
Survey	Who, What, Where, How many, How much?	No	Yes
Archival analysis	Who, What, Where, How many, How much?	No	Yes/No
Historical	How, Why?	No	No
Case study	How, Why?	No	Yes

3.5.2 Case Study Justification

As the current research involves mainly 'why' and 'how' types of questions, a case study strategy is adopted based on Yin's (2009) justification method. Therefore, case study is the most appropriate strategy especially regarding the resilience and vulnerability of the O&G industry in Bahrain. Case study assists in gaining rich descriptions and deep understandings (Van der Velde, Jansen and Anderson, 2004; Robson, 2002; Yin, 2009). Additionally, various scholars like Eisenhardt (1989), Robson (2002) and Yin (2009) have found that the case study is mostly appropriate in studying the contemporary events that require deep and broader understanding. Yin (2009) expressed case study as 'an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident'.

Conducting case study involves several streams of evidence like archival records, direct observations, interviews and documents (Yin, 2009). Moreover, Eisenhardt (1989) indicated that the case study can contain a number of data collection methods like interviews and questionnaire surveys, can include either qualitative or quantitative data and can be a mixture of both qualitative and quantitative data. Likewise, Yin (2009) pointed that case study can include many methods. However, Saunders et al. (2016) mentioned that interviews, observations, documentary analysis and questionnaires could be applied in the case study solely and in combination. By considering all that, the current research adopts the case study strategy through interviews, questionnaire surveys and documentations.

Apart from that, other research strategies are eliminated for several justifications. According to the research philosophical continuum and factors developed by Yin (2009), the archival analysis, experiment and history are inappropriate strategies for this research. Experiment is associated mostly with positivism continuum, is applied with a control group and tends to study causal links between variables. On the other hand, archival analysis strategy involves using administrative documents and records as primary data and the research aims to investigate changes of phenomena over a period of time. Moreover, historical research emphasises on previous events instead of contemporary events. Thus, the appropriate strategy for this research is a case study. This section has justified the rationale behind choosing case study as the most suitable strategy. The next section describes how case study method is adapted in this research in more details.

3.5.3 Case Study Design

Based on Yin's (2009) classification of case study, the basic design of case study is divided into four main types which are single-case holistic, single-case embedded, multiple-case holistic, or multiple-case embedded and they are shown in Figure 3.3. A single case study is applied in when the researcher is investigating unique circumstances, a critical case, a typical case, a revelatory case, or a longitudinal case (Yin, 2009). The current research involves the human error accidents in the O&G industry and its related challenges to enhance the industrial safety strategy which in fact does not meet the above criteria given for a single case study. Moreover, the downstream of the O&G industry in Bahrain consists of a number of units and each unit is considered as a sub-company that has its own unique characteristics and nature in term of operations, size, number of employees, contracts and management but collectively the performance and outcomes of these units represent the downstream as a whole. Therefore, as each unit plays a unique role and contributes differently to the downstream of the O&G industry in Bahrain, the single case study is not applied in this research. Accordingly, the multiple-case design and particularly a holistic multiple-case design is adapted in this research to present a holistic view that covers the downstream of the O&G industry in Bahrain. This design guarantees the best source of data for this research. Multiple-case design is used because it is more compelling and robust (Herriott and Firestone, 1983), promotes replication logic, supports theoretical generalisations and extends the breath of the research (Yin, 2009). Further, multiple case study research is useful in increasing the external validity and in reducing the observer bias (Voss, Tsikriktsis & Frohlich, 2002).

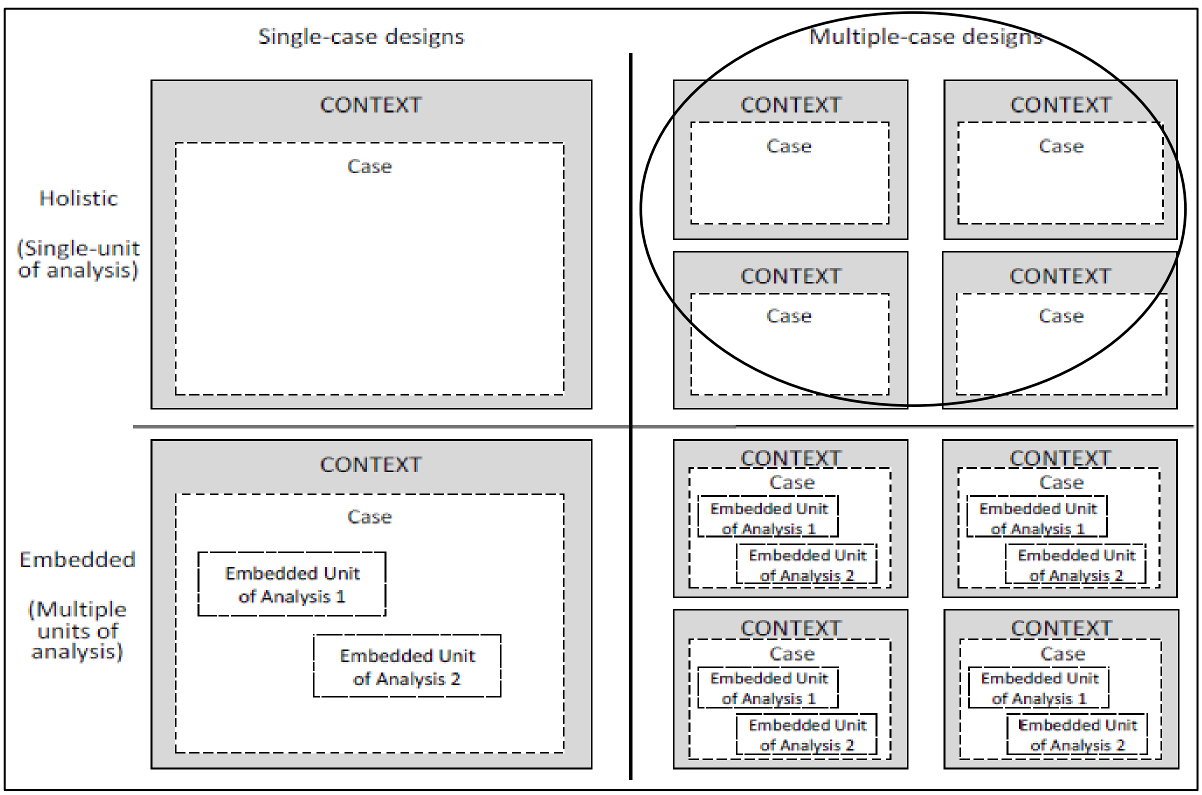

Figure 3.3: Basic Types of Designs for Case Studies (Source: Yin, 2009)

Accordingly, the cases of this study included units of the downstream of the O&G industry in Bahrain. Prior to case selection, it is vital to describe case study boundaries. The O&G industry in Bahrain and particularly the downstream was selected as a highly suitable stream to conduct the empirical study because it has a key part role in the economy, provides a wide range of jobs and employment, is the focus of recent long-term developments and it is a source of long-term cash

(OBG, 2017) as discussed in section 1.5 in Chapter 1. The downstream in Bahrain composed of a cluster of oil refiner and petroleum industries and others. On the other hand, the downstream is a highly competitive, risky and complex stream in the O&G industry in Bahrain. Despite that and the many challenges in the O&G industry in Bahrain face which were discussed in section 2.9 in Chapter 2, the downstream in Bahrain should continue to have a pivotal role in the future and to be robust, reliable, resilient, safe source of energy internally and externally. Accordingly, OHS issues in this stream must be kept in mind to maintain healthy and safe working conditions. Based on that, this research focuses on human error accidents in the downstream of the O&G industry in Bahrain. The case study area is shown in Figure3.4.

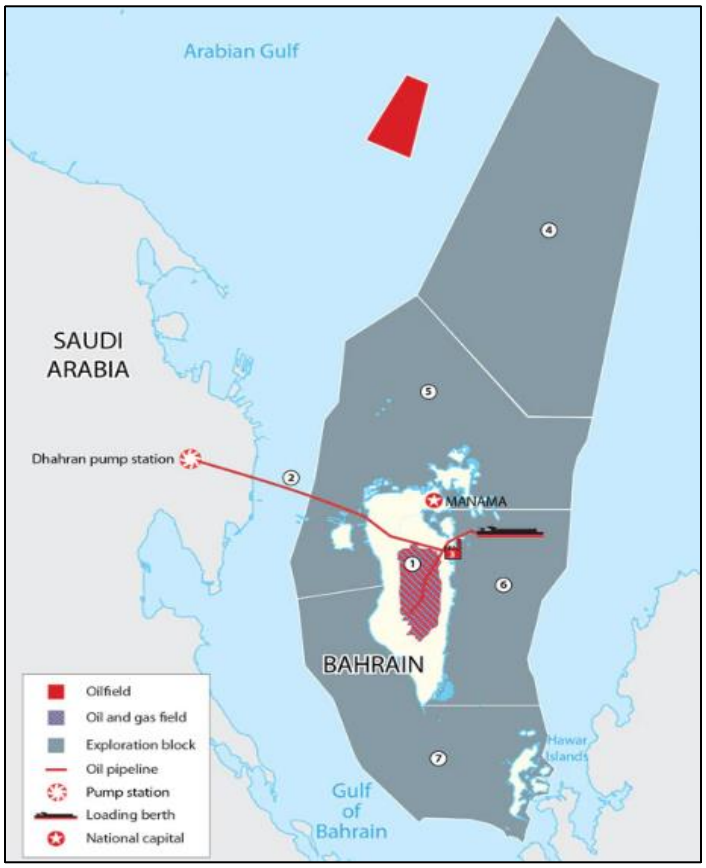

Figure 3.4: Case Study Area, (Source: The Oil and Gas Year TOGY, 2013)

Apart from that, it is important to describe the process of selecting the appropriate cases for this research. This process deals with searching for all necessary criteria to justify the selection of final case(s). In other words, it tends to answer why Case A is more preferred than other alternative case(s). A purposive sampling is one of the most common selection procedure of finding a good case (Seawright and Gerring, 2008). According to Seawright and Gerring (2008) is a stratified sampling technique that depends on a list of predetermined criteria to indicate the appropriate case/cases for a research. From the point of view of Rowley (2002), time, accessibility and resources are the three case selection criteria. While from the point of view of Seawright and Gerring (2008) time, money, expertise, access, and theoretical prominence of a specific case are the five selection criteria. Yin (2003), Stake (1995), Seawright and Gerring (2008) supported the argument of Rowley (2002). However, Seawright and Gerring (2008) pointed out that still there is no standards methodological justification for why case A might be preferred over case B. In this research, a purposive case selection process was carried out based on several criteria that were stemmed from Rowley (2002) argument and from with the current situation of the downstream in Bahrain. The potential for high risks and explosion, the potential for high number of human error accidents, the highest numbers of employment and the attention of most future expansion development projects and strategies are four criteria derived from the current situation of the downstream in Bahrain. The suggested criteria for purposive sampling of cases are presented in Figure 3.5.

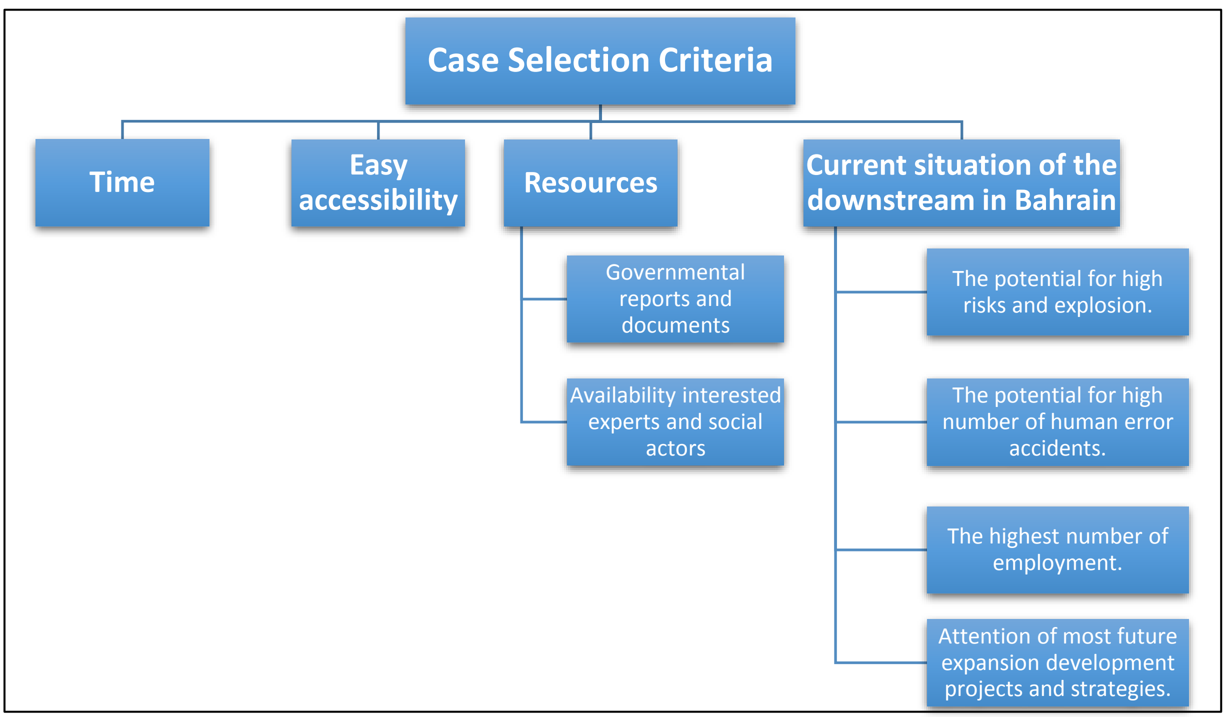

Figure 3.5: Case Selection Criteria

Furthermore, Yin (2014) described that there is no predefined formula or way that indicates the best number of cases. Based on Yin's (2014) and the selection criteria, three units were selected for study areas from the downstream, namely refining unit, distributing unit and storage unit as presented in Table 3.5.

Table 3.5: The Selected Cases

Case No.	Unit	Descripting
Case 1	**Refining unit**	It processes and transforms crude O&G to many useful products like gasoline and diesel (Devold, 2013).
Case 2	**Distributing unit**	It composes of steel rigid tanks and containers to store O&G (Fabbrocino, Iervolino, Orlando & Salzano, 2005).
Case 3	**Storage unit**	It distributes O&G through complex networks to O&G consumers (Hasan, Ghannam & Esmail, 2010).

Time restrictions, access to cases and data saturation factors also were considered to decide the required number of cases. Particularly, this research is conducted on only refining, distributing and storage units due to their key role in the downstream. These units are becoming typical because they represent the future of the downstream in specific and the overall O&G industry in Bahrain in general. However, as the literature chapter mentioned that there is no research or investigation efforts that are targeted the O&G industry in Bahrain in term of human error accidents and with this level of access in the past, the information, experience and knowledge that could be acquired from these three units would be essential and important internally for Bahrain in future and regionally for other GCC countries.

3.5.3.1 Unit of Analysis

Unit of analysis is defined as the phenomenon under study, about which data is gathered and analysed (Collis and Hussey, 2009). Yin (2009) noted that it is related to the core problems of defining what the 'case' is (Yin, 2009). Neuman (2011) indicated that the case could be formed as groups, individuals, organisations, events, or geographic units. Based on the aim of the current research, the unit of analysis is 'downstream unit' and the boundary of the case is 'human error accidents in the O&G industry in Bahrain'. In this regard, the most relevant case studies are chosen in this research because of the nature of the units in the downstream. The current research strategy is applied on A Company because it is the backbone of the downstream of the O&G industry in Bahrain.

3.5.3.2 Theory Building

As case studies are applied to afford description, test theory, or build theory, Eisenhardt (1989) that theory can be built based on the prior literature, common sense and experience. The theory building in this research depends on abductive approach. An outline of the main processes in this theory building is represented in Figure 3.6.

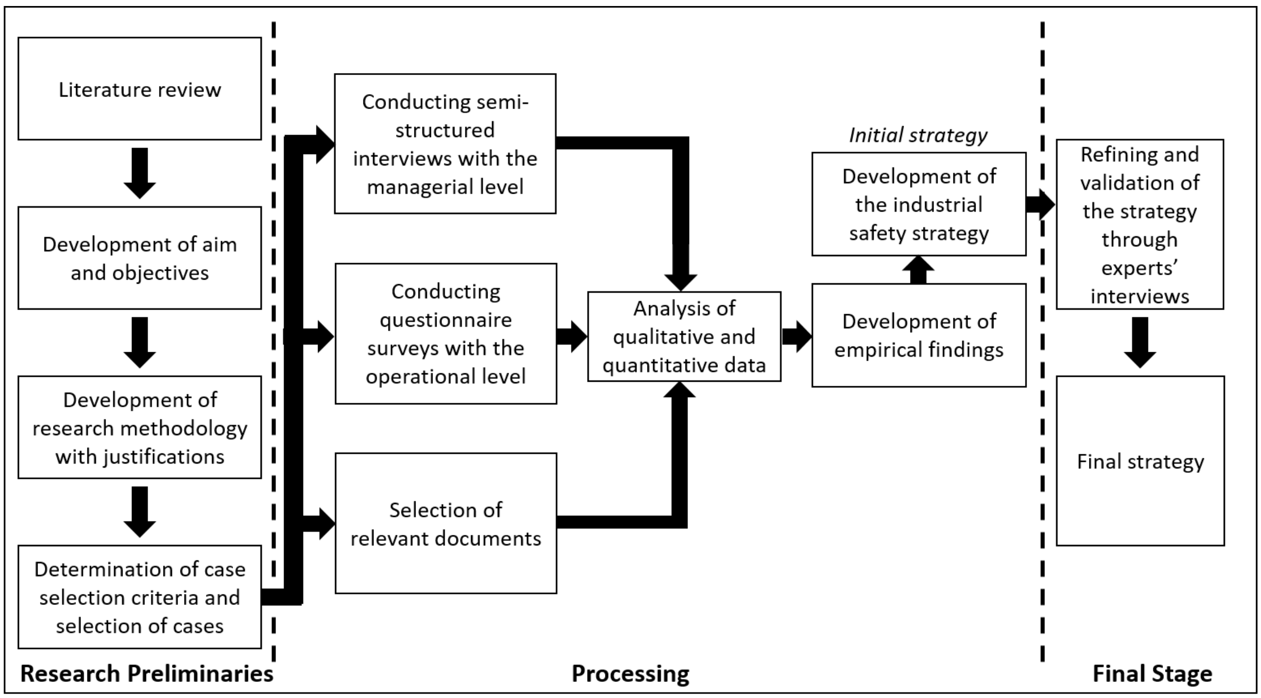

Figure 3.6: Theory Building in This Research

Based on Figure 3.6, the abductive approach involves a critical review of literature, semi-structured interviews with the managerial level, questionnaire surveys with the operational level and documentation. The qualitative and quantitative data collected from all these methods are analysed using proper qualitative and quantitative methods in order to develop a theory. The next section illustrates the fourth layer of research onion which is the research choice.

3.6 Research Choice

Research choice specifies whether the researcher is willing to apply the qualitative method solely, quantitative method solely, or a mixture of these two methods (Saunders et al., 2012). Thus, a research can be either qualitative which focuses on words and observations in order to analyse and interpret the surrounded world and endeavors to express individuals in natural terms, or quantitative which concentrates on numerical data to represent opinions and perceptions (Amaratunga, Baldry, Sarshar & Newton, 2002). Collis and Hussey (2009) have called the qualitative data as data in nominal form while the quantitative data as data in numerical form. Furthermore, a research can be a combination of both which is the mixed method (Teddlie and Tashakkori, 2009). Table 3.6 shows dimension of contrast between research choices.

Table 3.6: Dimension of Contrast between Research Choices (Source: Teddlie and Tashakkori, 2009)

Dimension of contrast	Qualitative position	Mixed method position	Quantitative position
Methods	Qualitative methods	Mixed method	Quantitative methods
Researches	QUALs	Mixed methodologists	QUANs
Paradigms	Constructivism(and variants)	Pragmatism; transformative Perspective	Postpositivism positivism
Research Questions	QUAL research questions	MM research questions (QUAN + QUAL)	QUAN research questions; research hypothesis
Form of data	Typically narrative	Narrative + numeric	Typically numeric
Purpose of research	(Often) explanatory + confirmatory	Confirmatory + exploratory	(Often) confirmatory + exploratory
Role of theory; Logic	Grounded theory; inductive logic	Both inductive and deductive logic; inductive and deductive research style	Rooted in conceptual framework or theory; hypothetico-deductive model
Typical studies or designs	Ethnographic research design and others(case study)	MM design, such as parallel and sequential	Correlational; survey; experimental; quasi-experimental
Sampling	Mostly purposive	Probability, purposive and mixed	Mostly probability

Data analysis	Thematic strategies: Categorical and Contextualizing	Integration of thematic and statistical; data conversion	Statistical analyses; descriptive and inferential
Validity/trust worthiness issues	Trust worthiness; Credibility; transferability	Inference quality; inference transferability	Internal validity; external validity

Mixed methods are applied where the qualitative and quantitative data are provided concurrently (Creswell & Zhang, 2009; Saunders et al., 2012) to provide depth and breadth facts and figures (Al Zefeiti & Mohamad, 2015; Sale, Lohfeld & Brazil, 2002). Mixed methods promote a higher results' confidence, more innovative methods, ways of addressing a problem and a chance to explore the unexpected dimension of a phenomenon (Onwuegbuzie & Leech, 2006). On top of that, it contributes positively to the level of reliability and credibility of the research (Abowitz and Toole, 2010). Section 3.9 provides more details about these terms. According to the characteristics of the mixed methods, this research used the mixed methods approach in order to achieve the research aim and objectives. This means that the mixed methods support this research in providing multiple perspectives and more completed understandings for human error accidents in the O&G industry in Bahrain. It assists in overcoming the limitations of each method and in filling and predicting the gaps of data. Within this method also, a researcher can apply the most suitable methods for collecting and analysing data. For instance, the quantitative part explains several practices to determine the critical challenges that are analysed using mathematical methods while the qualitative part explores deeply human error accidents scheme and the current OHS framework based on how the managerial and operational level view and experience the environment in the downstream.

3.7 Time Horizon

Time horizon specifies whether a research is a cross-sectional study that focuses on one particular time or a longitudinal study that stretches over a period of time (Saunders et al., 2012). Within a cross-sectional study, the researcher tends to investigate a particular phenomenon at a specific time, while in comparison, within a longitudinal study, the researcher tends to investigate the variations occurred to a phenomena over a timescale. Saunders et al. (2012) noted that most academic courses are cross-sectional studies due to the time restriction. This study is not concerned on investigating the changes over a period, or comparing between changes from one particular time to another. Therefore, a cross-sectional research is adapted to take a snapshot at a single point of time in the O&G industry in Bahrain in order to address the proposed objectives.

3.8 Research Techniques

This section is designed to discuss the techniques that have been used in this research in order to collect and analyse the data. The qualitative and quantitative data are collected through the mixed methods using the semi-structured interviews, questionnaire surveys and documentation respectively.

3.8.1 Data Collection

In general, data can be collected through many ways. Archival material, observations, interviews or questionnaires are some examples (Collis and Hussey, 2009; Easterby-Smith et al., 2012). The appropriate method for a study can be chosen based on the specific research requirements, research philosophy, research approach, research strategy, and research objectives (Yin, 2009). Hussey and Hussey (1997) found that data collection is divided into primary data and secondary data. The primary data is information gathered especially for the purpose of a study while the secondary data is information collected for another purpose but linked to the investigated phenomena of the study in order to form the theoretical base for that study. Secondary data are like papers, research, articles, reference books, theses, magazines and the internet. Within the current research, primary and secondary data were adapted.

Accordingly, three data collection techniques were used: semi-structured interviews for the managerial level; questionnaire surveys for the operational level; and document survey. The first one is the semi-structured interview for the managerial level of the three units in the downstream. It used to provide a new insight, identify general patterns (Robson, 2002) and describe the real scheme and relationships between variables (Saunders & Thornhill, 2003). Applying semi-structured interviews is derivative from Kaplan and Duchon's (1988) belief that an interview is an appropriate technique for studies in which a research is in its early phases, and where the context and participants are of particular importance to the study. Additionally, it is used to promote a high level of flexibility, response rate and control over the environment, questions, time, date and place. The second data collection technique is the questionnaire survey for the operational level of the three units in the downstream. It is applied because it is a quick, cheap and highly structured data collection instrument (Bell & Lederman, 2003) for generalisation. In addition, it is broadly applied especially in management and business research (Saunders & Thornhill, 2003). As well as, it has a great ability to cover easily a large number of participants from the operational level of the O&G industry in Bahrain. The last data collection technique is document survey. It is used to overcome researcher's bias and increase the reliability of the data collected (Denzin & Lincoln, 2000; Yin, 2009). In other words, it is applied to eliminate any possibility of low reliability of the acquired data from the semi-structure interviews and questionnaire. Annual and quarter reports from BEDB and government legislation and MOL's accident statistics are some examples. Yin (2009) and Denzin and Lincoln (2000) have affirmed that using documentation as one of data collection methods in a research can strongly support evidence gathered by other methods.

Thus, data triangulation approach is applied as there is no single method ever adequately solves any problem (Denzin, 1978). Undoubtedly, data triangulation avoids the bias and adds more validity, reliability and credibility to the final conclusion (Easterby-Smith et al., 2012) which helps in enhancing the industrial safety strategy to the O&G industry in Bahrain. Additionally, it increases the ability of generalisation effectively and professionally (Easterby-Smith et al., 2012) and this is particularly utmost important in the O&G industry during the lack of scientific studies in this regard.

The next section present one of the adapted data collection method in this research which the semi-structured interview.

3.8.1.1 Semi-Structured Interviews

One of common methods for collecting data in the case study is interview because it gives deep and broader understanding on the investigated phenomenon. An interview means that the chosen interviewees are asked several questions to know what they do, know, think or feel about a specific matter (Hussey and Hussey, 1997). Vincoli (1993) related the success of an interview by some characteristics of the interviewer which are objectivity, professionalism, and ability to properly assess and interpret the acquired information and to be friendly with interviewees. Structured interview, semi-structured interview, and unstructured interview are the three types of interview. Determining the suitable type of interview for a research relies on the proposed aim and objectives and the adapted strategy.

First, a structured interview means that there is a predefined list of sequential questions to be asked. In this case, it is called 'quantitative research interview' because it tends to gather quantifiable data (Saunders et al., 2016). It is useful in collecting uniform information that guarantees the comparability of data (Oppenheim, 1996). Second, an unstructured interview means that there is no predefined list of questions to be asked. This type is mostly used for exploring a topic as the interviewer is able to ask the interviewees freely regarding the phenomena. In this case, the interviewer should have a clear knowledge about the important aspects and issues that should be investigated and explored as there is no predefined reference for the questions (Saunders et al., 2016). Finally, a semi-structured interview means that there is a list of predetermined questions but this list is flexible for expansion or reduction depending on the flow of the discussion.

Based on the characteristics of each type, the structured interview and the unstructured-interview are not applied in this research. The structured interview is not appropriate as it tends to quantify a certain issue and the unstructured-interview is also not suitable as it can lead to misleading and other problems. Therefore, the researcher adopted the semi-structured interview in the current research to acquire a wider understanding of the setting of human error accidents in the O&G industry in Bahrain and to understand clearly the current situation of OHS framework in Bahrain. This helps in identifying the main challenges related to this setting in order to mitigate them while enhancing the industrial safety strategy. Simply, semi-structured interview helps in obtaining the views, beliefs and attitudes in term of human error accidents. Many professionals including Sekaran and Bougie (2016) and Yin (2009) asserted the importance of testing the questions that will be asked in the interviews or questionnaires during a pilot study. Therefore, questions were developed and piloted in order to ensure that the questions are easy to perceive, understand, interpret and follow and easy to gain information from interviewees. The questions were administered to 4 researchers who have experience in the O&G industry. The results from this pilot study indicated that several revisions were required to particular questions like changing some words and adding more explanations for some questions. These results were addressed. The sampling procedure for the semi-structure interview is presented in the next sub-section.

3.8.1.1.1 Semi-structured Interview Sampling Procedure

Sampling is an essential requirement for the current research as collecting data from the whole population is not practicable. Simply, sampling means selecting a group of individuals or things selected from a larger population (Scott & Morrison, 2007) in order to represent a particular population (Gall, Gall & Borg, 2007; Neuman, 2011). Sampling techniques are probability sampling and non-probability sampling (Saunders et al., 2012; Denscombe, 2010; Easterby-Smith et al., 2012). When the probability of every individual in the population to be involved in the sampling is known, this is called probability sampling, whereas when it is unknown, it is called in non-probability sampling (Easterby-Smith et al., 2012). As the appropriate technique depends on the nature of the research, non-probability sampling was used for selecting the participants for the semi-structured interviews. There are five types of non-probability sampling which are quota sampling, purposive sampling, snowball sampling, self-selection sampling, and convenience sampling (Saunders et al., 2012). Among all these five types, purposive sampling is the most suitable sampling method for the semi-structured interviews. In this case, the sample is chosen depending on its relevance and knowledge (Denscombe, 2010). Relevance assumes that interviewees are selected based on how they are related with the phenomena or theory being investigated. Knowledge assumes that interviewees are selected based on their knowledge or experience regarding this phenomena. This sampling technique is used for the semi-structure interviews to recruit participants from the managerial level of the refining, distributing and storage units in the downstream.

Participants of the managerial level were selected from these three units based on several criteria like occupation, educational and professional qualification, experience and safety background as shown in Table 3.7. Thus, they should be occupied with manager title or other equivalent titles. They should be in a leading position and should be a key contributor in the strategic plans and decisions in their relevant unit. They should have daily interactions and supervision over the employees in the operational level of these three units. They should be educated and qualified with professional qualifications. They should have at least 10 years of experience in these three units. They should have at least a basic background in safety.

Table 3.7: The Managerial Level Selection Criteria

Selection Criteria for the Managerial Level	Description
Occupation	1. They should be occupied with manager title or other equivalent titles. 2. They should be in a leading position and should be a key contributor in the strategic plans and decisions in their relevant unit. 3. They should have daily interactions and supervision over the employees in the operational level of the refining, distribution and storage units.
Educational/ professional qualification	4. They should be educated and qualified with professional qualifications.
Experience	5. They should have at least 10 years of experience in these three units.
Safety background	6. They should have at least a basic background in safety.

Particularly, in the first week of May 2017 the researcher contacted and met a responsible representative from Company A to give idea about the research and the type of support needed to schedule the semi-structured interviews and administrate the distribution of questionnaire surveys. The representative works as an administrative for the refining, distributing and storage units in Company A. Based on the selection criteria of the managerial level and through the company database and existing personal contacts, the representative invited the appropriate managers via an email to participate in this research. In this email, the representative mentioned to the managers that they can accept or refuse to participate in this research and if anyone accepts to participate, he/she has to send him an email. Once the representative received the acceptance from a manager, he sent some useful materials like ‘participant information sheet’ (see Appendix 2) and the interview guidelines (see Appendix 4) to this particular manager to give a brief overview of the research, important areas and aspects to be covered and the extent of involvement. Finally, this representative scheduled a day for a semi-structured interview on agreement between the researcher and the manger.

After that, using a face-to-face or in person interview method, the interviewer conducted the interviews in Company A. These interviews were conducted between June and July 2017. The researcher started all the interviews with an introduction for the overall research, aim, objectives, organisation of the interview, and ethics of the interview. After that, researcher asked all interviewees to sign the consent form and sought their permission to digitally record the interview. 12 managers from the refining, distributing and storage units were participated in the interviews. Having a variety of occupations within the managerial level strengthens the validity through the triangulation of data by gaining various viewpoints. One of the twelve managers (Interviewee 3) works in NOGA and he is responsible for supervising the downstream operations and especially the refining unit because he had a previous experience in the refining unit. The total number of interviews was 12 because having this number of interviews for the managers of the downstream of the three units was saturated. This means that at this number of interviews there was almost no further information identified by participants. According to Guest and Kathleen (2008), data becomes saturated after analysing as early as 12 interviews while the basic themes were determined after the first six interviews. Managers who participated have different backgrounds, such as distribution manager, refining manager, storage manager, HSE manager and oil process superintendent and other equivalent titles. Managers have different experiences and expertise in the downstream of the O&G industry. Table 3.8 present some details data about the participated interviewees. More details about those interviewees are provided in Chapter 4.

Table 3.8: List of Interviewees, Occupation and the Belonging Unit

Interviewee No.	Occupation	Case Study		
		Refining Unit	Distributing Unit	Storage Unit
Interviewee 1	Refining operation superintendent	✓		
Interviewee 2	Health, safety and environment manager	✓		
Interviewee 3	O&G development manager	✓		
Interviewee 4	Operation superintendent	✓		
Interviewee 5	Distribution operation superintendent		✓	
Interviewee 6	Chemical processing superintendent		✓	
Interviewee 7	Planning superintendent		✓	
Interviewee 8	Distribution manager		✓	
Interviewee 9	Storage operation superintendent			✓
Interviewee 10	Storage manager			✓
Interviewee 11	Technical service superintendent			✓
Interviewee 12	Manager Manufacturing design and analysis superintendent			✓

The next section discusses the second data collection method which is the questionnaire survey.

3.8.1.2 Questionnaire Survey

The second type of data collection method in the current research is questionnaire survey. A questionnaire is a multipurpose tool which integrates different perspectives of the invested phenomena. This instrument is capable of providing both qualitative and quantitative data. It composes of a set of different types of questions that are ranked based on the interest and values of the researcher (Garcia, 2003). According to Saunders et al. (2012), they pointed out that questionnaire survey is often the only capable method to draw a holistic picture about the characteristics and behaviour of a large population. Straightforwardness, speed, economy and efficiency are the main fruitful advantages of adapting questionnaire. On the other hand, Hussey and Hussey (1997) found several disadvantages in using questionnaire like low response rate and the difficulty of designing questions. Apart from that, the success of any questionnaire is depend on five factors which are challenge, concise, clarity, relevance and focus (Fonseca, 2012).

In the current research, the key objective of the current questionnaire is to quantify the magnitude of challenges regarding human error accidents. Additionally, the questionnaire is to get some important information regarding the O&G industry. Therefore, there were three main sections in the questionnaire: participant's background information, work information, and opinions on workplace. The first section consisted of two simple close-end questions with several selection options and one open-end question regarding their occupation. The second section consisted of seven simple close-end questions with particular selection options and one open-end question regarding their qualification. However, the category "other" was included in one of the close-end questions of the second section. This will particularly useful in exploring novel answers that the researcher did not predict or expect them in the development of the questions. The third part consisted of a wide rage close-end questions for scaling with five points Likert Scale 'Strongly disagree' = 1, 'Disagree' = 2, 'Neither agree or disagree' = 3, 'Agree' = 4, and 'Strongly agree' = 5, where respondents from the operational level were invited to judge and evaluate each one clearly. The third section of the questionnaire was developed to evaluate several challenges related to human error accidents based on some results of literature review. Particularly, this section focuses on some human factors that are at the same time challenges to different workplaces around the world (Vondráčková et al., 2017; Dumitru & Boşcoianu; 2015; Energy Networks Association, 2013; Gonçalves Filho et al., 2012; Shabin & Ramesh Babu, 2012). Focusing on these challenges assists in drawing a clear real picture for human error accidents context which in turn will contribute to build an effective action plan for enhancing the industrial safety strategy for the O&G industry in Bahrain. These challenges (constructs) are shown in Table 3.9.

Table 3.9: Constructs and Items in the Qestionnaire Survey

Challenges (Constructs)	Items	Number of items
Safety regulation	1. Safety policy ensures OHS and well-being of workers. 2. Safety policy is updated and improved regularly. 3. Safety policy, principles of action and objectives are written and documented. 4. Safety policy, standards and rules are clear to all workers. 5. Instruction manuals that elaborated to aid in preventive action are available to all.	5
Safety implementation	1. Safety plays a key role in job promotions. 2. The safety procedures and practices in this organisation are valuable and effective. 3. There are periodical safety inspections for all workplaces. 4. The safety rules and procedures assist in preventing accidents in the workplace.	4
Top management	1. Managers and supervisors often try to enforce safe working procedures. 2. Management regularly consults with employees about OHS issues in the workplace. 3. Safety committees exist in my company consisting of representatives of the managerial and operational levels.	3
Safety training	1. There is a sufficient training period for new employee, any change in the workplace or using new equipment. 2. Safety training is updated regularly and the training programme is well-organised.	3

	3. Workers are satisfied with the acquired educational level from training, as it will raise their job performance level.	
Safety leadership	1. Management inspires all employees to attend safety-training courses. 2. Management stimulates employees' involvement in OHS matters. 3. Managers are active and visible in addressing OHS matters. 4. Managers always visits the workplace to ensure safe working conditions and communicate with workers.	4
Communication	1. There are regular meetings, sessions, or oral presentations to transfer safety standards and rules of action. 2. Workers on this unit always ask another worker when they do not understand what to do. 3. Workers on this unit will continue to seek clarification/question the safety leadership when an order does not quite make sense. 4. Management allows workers to state their opinion before taking decisions on OHS matters.	4
Accidents reporting system	1. In my company, accident report is mandatory even if there is no injuries or damages. 2. In my company, accident investigation results are always shared among all workers. 3. In my company, recommended actions in accidents investigation reports are always taken place after accident.	3

Based on the importance of a pilot study, once the structured questionnaire was developed for the current research, it was piloted in March 2017. A pilot study assists in filtering and improving the overall design and wording of the proposed questions. The questions of the questionnaire were administered to 4 researchers who have experience in the O&G industry and they were asked to give their feedback regarding the syntax, structure, ambiguity and simplicity of questions and items in a feedback form. Feedback specifies if there is any difficult, missed or wrong factor. The results from this pilot study indicated that several revisions were required to the overall layout of the questionnaire with several spelling mistakes. Finally, the questions of the questionnaire was redraft and improved, for example, some words and questions were modified to be clearer. The finalised questionnaire consisted of 3 questions in the first section, 8 questions in the second section and 26 questions in the last section. It was written in English as an official language. However, during the designing phase of the questionnaire, several important points were considered like minimising any potential disruption to the O&G industry as a whole and the selected company in specific, guaranteeing the confidentiality and anonymity of all participants throughout all phases of the research, allowing the participant to withdraw freely at any stage without giving a reason and ensuring that the participation is voluntary in nature. The sampling technique that was used for selecting the participants for the questionnaire surveys is presented in the next sub-section.

3.8.1.2.1 Questionnaire Survey Sampling Procedure

As sampling is an essential requirement for collecting data from the operation level of the refining, distributing and storage units, probability sampling was used for selecting the participants for the questionnaire surveys. As the appropriate technique depends on the nature of the research, simple random sampling is the most sufficient technique for the questionnaire. It is simple and free from classification errors and it does not need any additional information. There are various formulas to determine the required sample size for a research. The sample size of the research has a critical impact on generating meaningful results. If the sample size was too small, it might be hard to identify the influence or phenomenon investigated and a matter of results inconclusive would arise. On the contrary, the sample size was too large, any small effect can be identified, the results would be of insignificant and time and resources would be wasted.

Due to the need for an efficient method of calculating sample size within the in empirical research, Krejcie & Morgan (1970) developed a table for determining the appropriate sample size for a given population as an easy reference. This table is developed for calculating the required size ‘S’ of a randomly chosen sample from a given finite population of ‘N’ cases such that the sample proportion ‘p’ will be within ± .05 of the population proportion ‘P’ with a 95 percent level of confidence. Using Krejcie and Morgan table for estimating the sample size in research is common (Chuan & Penyelidikan, 2006). In order to determine, the appropriate sample size, the table of Krejcie & Morgan (1970) was adapted. The total number of the workers in the operational level from the three units (refining, distributing and storage units) from Company A is 550 workers. This number was considered as the population in this research in order to identify the appropriate sample size. Based on this table, the appropriate sample size is 226 workers and this is shown in Table 3.10.

Table 3.10: Sample Size Table, (Source: Krejcie & Morgan, 1970)

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Based on that, the questionnaire was administered in May 2017 and completed in July 2017. As mentioned previously, in the first week of May 2017, the researcher contacted and met a responsible representative from Company A to schedule the semi-structured interviews and administrate the distribution of questionnaire surveys. Within this meeting, a hard copy of all-important documents like participant information sheet (see Appendix 2) were discussed with this representative. The representative was informed that the participants should be selected randomly and they should be with any position of the operational level of the refining, distributing and storage units. Based on that and using the company database and existing personal contacts, the representative sent an email to invite the employees to participate in the research. In this email, the representative mentioned to the employees that they can accept or refuse to participate in this research and if anyone accepts to participate he/she has to send him an email. Once the acceptance email was received, the representative sent the participant information sheet *(see Appendix 2)* for this participant and contacted him to get a copy of the consent letter to be signed and the questionnaire. The representative also informed the participant that he is able to withdraw at any stage of the questionnaire without giving any reasons. The representative also asked any participant to return the signed consent letter and questionnaire back by hand within 4-6 days.

Native and foreign workers participated in the questionnaire. The foreign workers are from Asian countries. Some foreign workers required a special discussion to understand precisely the purpose of the current research and the nature of their involvement. However, in few cases the representative called some translators to explain these issues clearly and overcome any misunderstanding with few foreign workers. 75 hard copies of the questionnaire survey were distributed over the operational level of each unit and one copy was given to the representative who is responsible for administrating these three units. Accordingly, the questionnaire was distributed over 226 potential respondents of that 163 (57 from refining unit, 52 from distributing unit and 54 from the storage unit) were valid and completed questionnaires. The profile of those participants of each unit is presented in section 4.4.1.1.1, section 4.4.2.1.1 and section 4.4.3.1.1 in Chapter 4. The response rate is 72%. This was very satisfactory.

The next section describes the analysis phase in this research to both qualitative data (semi-structured-interview) and quantitative data (questionnaire).

3.8.2 Data Analysis

Data analysis focuses on transferring the collected raw qualitative data, quantitative data or qualitative and quantitative data to meaningful forms using an appropriate programme. According to Creswell (2006), there are three ways to combine the qualitative and quantitative data as illustrated in Figure 3.7. The first one is by merging or combining the qualitative data and quantitative data together. The second one is by connecting one dataset with other dataset in which one is built based on the other one. The third one is by embedding one dataset within the other dataset in which one dataset supports other dataset. This research follows the first way of Creswell model. The results from semi-structure interviews and questionnaire surveys were gathered with the documentations in order to build the theory.

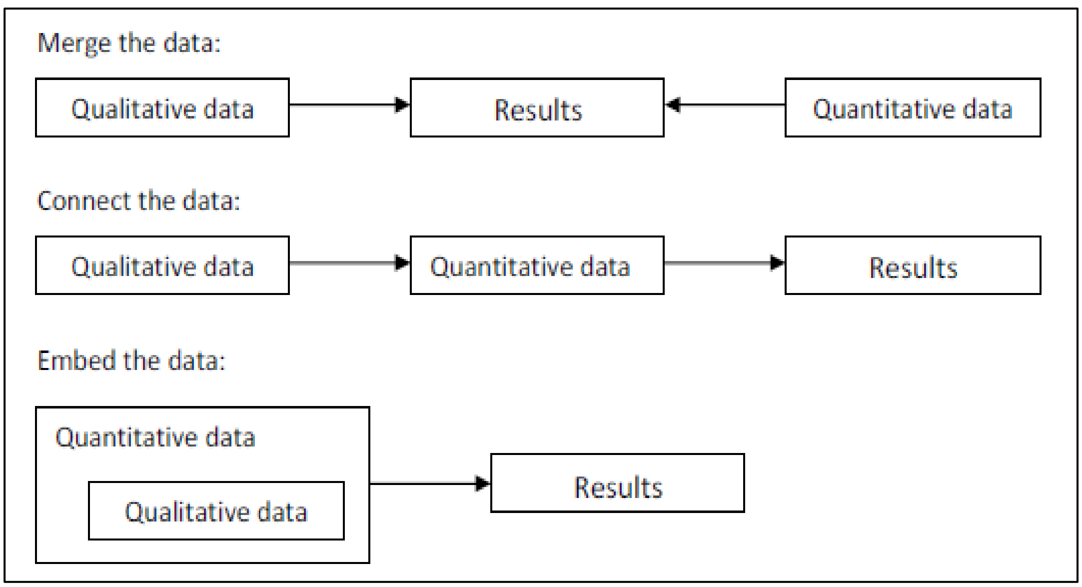

Figure 3.7: Ways of Mixing Quantitative and Qualitative Data (Source: Creswll, 2006)

From another point of view, Miles and Huberman (1994) have proposed a model that describes how to link quantitative and qualitative methods. It contains four ways for mixing quantitative and qualitative data as shown in Figure 3.8. In this research, the first way of this model is adopted. In this first way of mixing quantitative and qualitative data, the researcher started with both the qualitative data and the quantitative data methods simultaneously by interviewing the managerial level and distributing the questionnaire surveys over the operational level. The findings from these channels were integrated together to build the final conclusion.

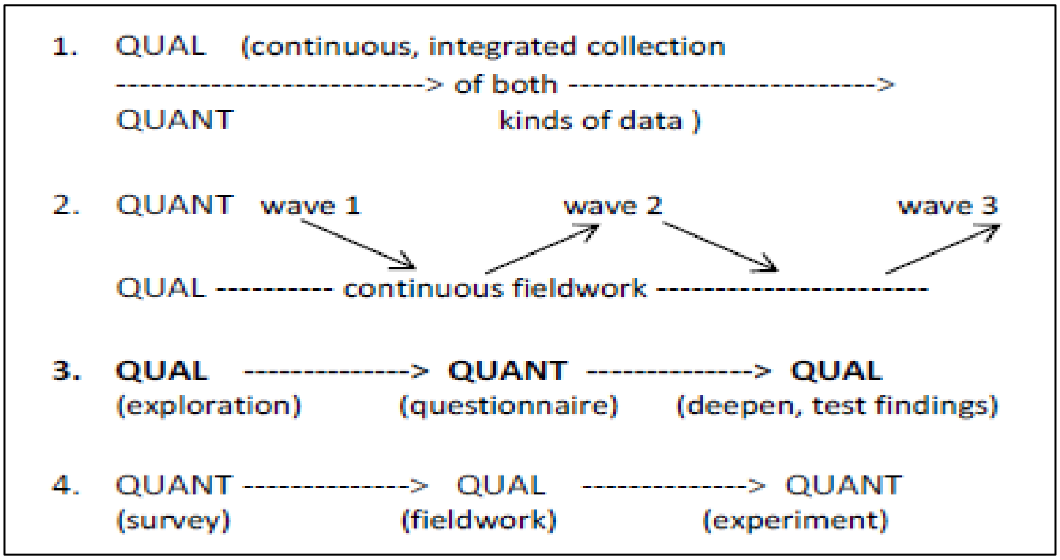

Figure 3.8: Illustrative Designs Linking Qualitative and Quantitative Data (Source: Miles and Huberman, 1994)

3.8.2.1 Content Analysis

Content analysis analyses the obtained qualitative data from interviews by quantifying it (Mayring, 2014). In other words, it is a systematic way to transfer text and words to meaningful numbers (Collis and Hussey, 2009). Additionally, Bryman and Bell (2011) indicated that content analysis is used for the qualitative research and they stated the qualitative content analysis as 'an approach to documents that emphasises the role of the researcher in the construction of the meaning of and in texts'. Based on the aforementioned definitions of content analysis and the objective of using the semi-structured interviews in the current research, this research applies the content analysis to analyse the interview transcripts in order to identify the emerging themes. It also used to draw a generalised conclusion from managers points of view (Neuendorf, 2002). Thus, it seeks to generate conclusions that can be applied to the whole O&G industry in Bahrain rather than being limited to the three units in the downstream. It is relatively cheap, and if it was done appropriately, it is a consistent analysis which can be checked easily and revised by others; thereby, these are some reasons of applying it.

Additionally, the content analysis is applied in this research taking advantage from a computer software package called NVivo (version 11.0) for several reasons. First, NVivo is a useful software package for both qualitative and mixed methods research. Second, it is capable of collecting and organising qualitative data, such as interview. Third, as this research has numbers of interviews and it is too hard to handle them manually; this software is an appropriate solution in term of a simplicity, ease of understanding, friendly user interface, rigorousness in analysing the data. Using the NVivo software involves transcribing the raw data (words and sentences) of the interviews in a word processing software (MsWord 2013 software), importing these data into NVivo, establishing the preliminary themes (nodes) and codes, developing the nodes, analysing the coded texts and finally receiving the results. In general, content analysis involves several numbers of stages, where the responses of interviewees should be read first. Then, they should be classified based on a specific condition. This stage is repeated to create smaller sub-classifications until there are no more classifications. Then, every sub-classification is revised in order to shrink the total number of classifications.

3.8.2.2 Questionnaire Survey Analysis

Analysing the questionnaire survey involves entering and coding the collected data, processing them through the most suitable software, and lastly conducting a descriptive and/or inferential statistical analysis to extract the important insights. Descriptive statistics are divided into central tendency measurement, dispersion measurement, percentile values and distribution measurement. Central tendency measurement is like mean, median and mode. Dispersion measurement is like range, standard deviation, variance, minimum and maximum. Percentile values are like quartiles and percentiles while distribution measurement is like skewness and kurtosis. In general, descriptive analysis is adapted usually to generate a summary for patterns. Central tendency is a significant to summarises or straightforward displays quantitative data (Collis and Hussey, 2009). It typically summarises data in a way to create clear visual graphics that represent the investigated phenomena. Thompson (2009) pointed out that descriptive analysis are more valuable for comparing results between different studies and this feature assists in identifying sample characteristics that may affect the final conclusions. On the other hand, inferential statistics are generally used to examine whether the data differs from the hypothetical value. It is applied in the current research due to several reasons. First, it is capable of drawing a general observation of large population (Gabrenya, 2003). Second, it is capable of generating more detailed interpretations about variables (Trochim & Donnelly, 2001). Chi-square, T-test, regression analysis and analysis of variance are some examples.

After collecting the questionnaires from the respondents in this current research, the analysing phase started by inputting these data in a suitable software for the statistical analysis and interpretation. Descriptive and inferential analyses are undertaken to analyse the results in the questionnaire surveys. There are various software packages for the quantitative analysis like STATA, SAS, R, MATLAB and Statistical Package for Social Sciences (SPSS). In this research, SPSS (version 24.0) is used because it is relatively simple and satisfies the researcher's data analysing requirements. The collected data from the questionnaire surveys were keyed into SPSS software manually using particular codes. As an example for coding process of these data, when a participant ticked 'Strongly disagree', the code that was entered in the SPSS software is '1'. The coding criteria was based on the 5- Likert scale. 'Strongly agree' was coded as '5', 'Agree' was coded as '4', 'Neither agree or disagree' was coded as '3', 'Disagree' was coded as '2' and 'Strongly disagree' was coded as '1'.

Having described the data collection and analysis methods and techniques of this research, the next section describes the connection between data collection techniques and research objectives.

3.8.2.3 Connection between Data Collection Techniques and Research Objectives

This section aims to present how research methodology is designed to meet the objectives of the research. Table 3.11 shows the connection between the objectives, research strategy, data collection and data analysis techniques.

Table 3.11: Strategy and Techniques to Accomplish Research Objectives

Objectives	Strategies	Data Collection Techniques	Data Analysis Techniques
Objective1: To define human errors and human factors within the context of accidents in general	Literature review	Secondary data	Content analysis
Objective2: To identify the current OHS legislation, regulations and implementation in the O&G industry in Bahrain.	Literature review Case study	Semi-structured interviews Documentation	Content analysis
Objective3: To evaluate critically the challenges related to human errors specific accidents in the O&G industry in Bahrain.	Case study	Semi-structured interviews Documentation Questionnaire surveys	Content analysis Descriptive statistical analysis Inferential statistical analysis
Objective4: To explore best safety practices from other O&G industries in developed and industrial countries.	Literature review Case study	Semi-structured interviews	Content analysis
Objective5: To refine and validate the recommendations of the industrial safety strategy for the O&G industry in Bahrain.	Literature review Case study	Semi-structured interviews Questionnaire surveys	Content analysis Descriptive statistical analysis Inferential statistical analysis

As all parameters in the methodological framework, from the outer layer in the research onion which is research philosophy to the inner layer in the research onion which is data collection techniques and analysis were illustrated, the next section describes the undertaken validity and reliability in this research.

3.9 Validity and Reliability

Validity and reliability are important terminologies that are used in examining the quality of a research. Validity and reliability indicate that data collection stage can be repeated having similar results (Yin, 2009). Easterby-Smith et al. (2012) stated validity as 'the extent to which measures and research findings provide accurate representation of the things they supposed to be describing'. In a simple expression, validity describes whether the research is accurately measuring what the research intend to measure (Collis and Hussey, 2009). While the term reliability describes whether the same measurement tool produce the same results when the research repeated over time (Bryman and Bell, 2011). This means that reliability focuses on the results in term of stability and consistency. Amaratunga et al. (2002) found that the reliability tends to decrease the biases and errors during the data collection.

Qualitative and quantitative researchers view these two concepts differently (Neuman, 2011). In spite of this difference, Morse, Barrett, Mayan, Olson & Spiers (2002) stated that these two concepts could be achieved if the verification strategies are considered rigorously throughout the research process. Various methods have been developed for validity and reliability by several researchers like Neuman (2011) and Onwuegbuzie & Johnson (2006). The current research applied the one developed by Yin (2009). He divided it into construct validity, internal validity, external validity, and reliability. To ensure the validity and reliability in this research, the researcher has tried to ensure the consistency in each phase and at all times, so similar results could be generated if any researcher will undertake the same processes.

First, construct validity is implemented within the data collection process to offer the right operational measures for the investigated phenomena or concepts (Yin, 2009). It can be achieved by using various sources of evidence. Accordingly, to meet the construct validity, this research adapts two data collection methods (semi-structure interviews and questionnaire surveys) and mixed methods approach (a mixture of quantitative and qualitative approaches). Second, internal validity is defined as providing cause and effect relationship where there are dependent variables affected by independent variables (Yin, 2009). It is mostly applied in the explanatory study. To meet the internal validity in this research, a clear research design has been adapted aligning with choosing the suitable methods that lead to high level of internal reliability. Moreover, during the data collection, a high priority was given to selecting the most proper strategy. Third, external validity is examining whether the results of the research can be generalised or not. External validity can be met during the design process. To meet the external validity in this research, the process of data collection (interview) and (questionnaire survey) and the use of multiple units are the ways to ensure that. Fourth, reliability which is a core concern of the current research is reached by building the case study protocol. This protocol is expressed precisely by a step-by-step process. Additionally, Saunders et al. (2012) indicated that the reliability of interviews is linked to bias. Therefore, in this research consideration was given to avoid the possibility of bias. This has been achieved by improving interviewees' perceptions through building a good relationship and trust with them, giving a clear introduction for the research before starting with the questions, giving emphasis to the anonymity and confidentiality of the participants, and lastly allowing the interviewees to talk as they felt inclined.

Apart from all that, a Cronbach's alpha reliability coefficient was conducted to assess the reliability of questionnaire survey. Cronbach's Alpha is widely used in the social and organisational sciences (Cronbach, 1951). It became commonly adapted since 1951 when Cronbach (1951) discussed it and reasonably suggested the usage of the symbol 'α' as a shortcut for measuring the internal consistency reliability. According to Cortina (1993), Cronbach's Alpha is considered as an essential and pervasive statistics for testing the constructs. Alpha is a scale, an indicator or an instrument quality that measures attitudes and other affective constructs (Taber, 2018). Alpha is called in different studies as an indicator of reliability, internal reliability, interrater reliability and/or internal consistency. When the measurements represent multiple questionnaire/test items, which is the most common application, Cronbach's alpha is referred to as a measure of 'internal consistency' reliability (Bonett & Wright, 2015). As Cronbach's alpha reliability coefficient is normally between 0 and 1, George and Mallerys' (2003) rules of thumb was applied in this research. The rule of thumbs is shown in Table 3.12.

Table 3.12: George and Mallerys' (2003) Rules of Thumb for Internal Reliability

Cronbach's Alpha	> .9	> .8	> .7	> .6	> .5	< .5
Rule of Thumbs	*Excellent*	*Good*	*Acceptable*	*Questionable*	*Poor*	*Unacceptable*

The results of Cronbach's alpha reliability for the seven constructs of the questionnaire survey are shown in Table 3.13.

Table 3.13: Reliability Statistic for the Seven Constructs of the Questionnaire Survey

Construct	N of Items	Cronbach's Alpha*
Safety_regulation	5	0.76
Safety_implementation	4	0.79
Top_management	3	0.85
Safety_training	3	0.82
Safety_leadership	4	0.89
Communication	4	0.74
Accidents_reporting_system	3	0.83
Total	**26**	**0.93**

Based on the results in Table 3.13, the internal reliability for all the constructs of all scales is greater than (0.70). The highest value for the Cronbach alpha is for the construct of *Safety_leadership* which is (0.89). The lowest value for the Cronbach alpha is for the construct of *Communication* with (0.74). Since the internal reliability of all constructs are acceptable, the internal consistency of homogeneity of the measures is confirmed. In addition, Table 3.13 shows that the total Cronbach alpha that confirms of the reliability questionnaire survey is equaled to (0.93). This very high score indicates that the instrument has reflected a high degree of reliability and achieved the objectives of the study. Accordingly, the values of the correlation coefficient and consistency for almost all statements are high and statistically functioned which confirm the questionnaire validity.

3.10 Ethical Considerations

The research is guided by the United Kingdom Research Information (UKRIO) code of practice for research as this research falling under the category of 'Science and Technology'. All participants had been given all the necessary details of the research context and their level of involvement. This was achieved by obtaining their informed consent to ensure their involvement in the research. All the collected data are kept secure and confidential to maintain anonymity of the participants at every phase of the research. The reason was to ensure that the participant's anonymity was maintained throughout the research. The information also included informing the participants that their involvement was voluntary and they could withdraw at any stage without giving any reason for the withdrawal.

Ethical approval was provided to the research by the University of Salford after fulfilling all the ethical requirements. After completion, the approval allowed the researcher to continue to gather data collection and recruit participants for the interviews and questionnaire surveys. A copy of the ethical approval letter is provided on Appendix 7: Ethical Approval Letter.

3.11 Chapter Summary

This chapter has presented the adapted methodological framework in this study in order to achieve the current aim and objectives. The philosophical paradigm, approaches strategies and data collection methods have been discussed with their selection justifications. The deductive and inductive methods and the justifications of adapting the abductive approach are also explained. The research strategy tends to collect data from the refining, distributing and storage units in the downstream of the O&G industry in Bahrain. The decision to use semi-structured interviews, questionnaires, and documentations as the main sources of data for this research has been completely rationalised. At the end, the data collection and analysis process is illustrated. The next chapter expresses the results of analysing the collected data.

CHAPTER 4: RESEARCH RESULTS AND ANALYSIS

4.1 Introduction

This research aims to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan. This chapter presents and analyses the collected data from the refining, distributing and storage units of the downstream of the O&G industry in Bahrain. The primary data collection in this research were semi-structured interviews for the managerial level, questionnaire surveys for the operational level and documentation. The language used in both data collection was English as an official language in O&G industry in Bahrain. Case study analysis is provided for each case in this chapter. Then, a cross-case analysis is provided for the qualitative data and a cross-case analysis is provided for the quantitative data. After that, the document analysis is presented. The results from these analyses are expected to add several alterations in this company and the overall industry, make a streamlined guidance to implement an industrial safety strategy and improve legal measures like OHS framework and safety enforcements. On an academic level, these results are expected also to contribute to the body of knowledge existing currently in safety in the manufacturing sector and especially in O&G industry. The limitations of the obtained results and the adapted tools in this research are also addressed.

4.2 Background of Cases and the Adopted Procedures for Case Study Analysis

This section tends to discuss the data analysis of the case studies. A wider discussion for the three units (refining, distributing and storage) is provided aligning with the main results of each unit. These results are shown based on four criteria which are general overview on OHS framework in O&G industry, challenges related to human errors specific accidents in O&G industry in Bahrain, adapted best safety practices and the need for safety strategy in O&G industry in Bahrain. Each criterion has different sub-classifications to present the results clearly. This chapter starts first with describing the adopted procedures in analysing the case study and background of the cases. Then, the analysis of each case is presented individually.

The downstream in O&G industry in Bahrain is a complex workplace that consists of various units with complicated long procedures as mentioned previously. This research was conducted particularly on the downstream due to the economic importance of this stream and the high challenges and risks faced by it in comparison to the upstream as stated in Chapter 1. As a mean of illustration, three cases were conducted in this research within three units of the downstream which are refining, distributing and storage unit. These three units were selected based on their key role in representing the future of the downstream in specific and the overall O&G industry in Bahrain in general. Among different downstream companies in Bahrain, Company A was selected to participate in this research because this company is the backbone of the downstream of the O&G industry in Bahrain. These three units are located in Sitra industrial area in Bahrain As shown in Figure 4.1.

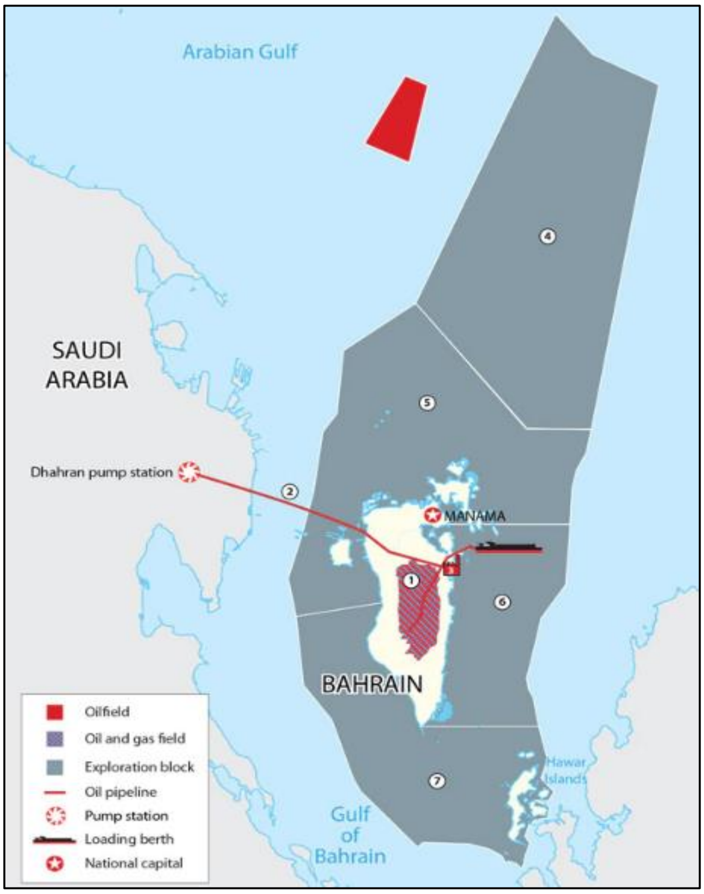

Figure 4.1: Study Area, (Source: TOGY, 2013)

The managerial and operational levels of these three units participated in this research. Through the semi-structured interviews with the managerial level, the qualitative data was collected. While through the questionnaire surveys for the operational level, the quantitative data was collected. These data were collected between May and July 2017 as presented in Chapter 3. The analysis of the semi-structured interviews, the analysis of the questionnaire surveys in each units and the cross-case analysis for each data type are discussed in this chapter. All the three cases are from Company A. Each case is illustrated in more detail in the following sections.

4.3 Case study Analysis for the Qualitative Data

Case study analysis is considered relatively as a new aspect of adapting case studies in a research and there is no defined proper strategy for this analysis (Yin, 2014). This analysis relies heavily on the empirical thinking and interpretation of the researcher. Therefore, general qualitative approaches that are used in analysing the interviews are considered in this chapter. Through the content analysis that depends on the researcher in interpreting the meaning of words and texts (Bryman and Bell, 2011), this research identified the emerging themes from the interviews transcripts using NVivo 11.0 software with multiple stages. Accordingly, after importing the transcripts in this software, themes (nodes) and codes were established, nodes were developed, the coded texts were analysed and finally the results were received. According to Yin (2014), a multiple case study report consists of sections on each case study in addition to a comprehensive section on the cross-case study. The results of each case study and of the cross-case analysis are presented in this chapter.

Twelve semi-structured interviews were conducted within these three units (4 semi-structured interviews within each unit). Table 4.1 represents these interviews along with the belonging units and interviewees details.

Table 4.1: Interviewees' Profile in Each Case

Case	Interviewee No.	Age	Occupation	Safety Qualifications	Years of Experience
Case 1: Refining Unit	**Interviewee 1**	50 - 60 years	Refining operation superintendent	NEBOSH Certification	More than 30 years
	Interviewee 2	50 - 60 years	Health Safety Environment manager	Firefighting Certification	More than 30 years
	Interviewee 3	40 - 50 years	O&G development manager	Firefighting Certification	25 - 30 years
	Interviewee 4	40 - 50 years	Operation superintendent	NEBOSH Certification and Firefighting Certification	25 - 30 years
Case 2: Distributing Unit	**Interviewee 5**	50 - 60 years	Distribution operation superintendent	Firefighting Certification	More than 30 years
	Interviewee 6	50 - 60 years	Chemical processing superintendent	NEBOSH Certification and Firefighting Certification	More than 30 years
	Interviewee 7	50 - 60 years	Planning superintendent	Firefighting Certification	25 - 30 years
	Interviewee 8	40 - 50 years	Distribution manager	NEBOSH Certification	More than 30 years
	Interviewee 9	50 - 60 years	Storage operation superintendent	Firefighting Certification	25 - 30 years

Case 3: Storage Unit	**Interviewee 10**	50 - 60 years	Storage manager	NEBOSH Certification and Firefighting Certification	More than 30 years
	Interviewee 11	40 - 50 years	Technical service superintendent	NEBOSH Certification	More than 30 years
	Interviewee 12	40 - 50 years	Manager Manufacturing design and analysis superintendent	NEBOSH Certification and Firefighting Certification	25 - 30 years

4.3.1 Case 1: Refining Unit

Refining unit is responsible for providing specific types of products based on predefined specifications for the quality and quantity of the end products (Devold, 2013). This unit runs twenty-four hours a day. The outputs (products) of this unit are used in heating homes, fuelling vehicles and running industry. Oil products are vital parts of modern society and oil will remain a significant energy source globally (Watson & Vandervell, 2006). Refining unit is a large-scale industrial complex because it has a wide range of very complicated process like cracking, reforming, additives and blending the crudes in order to produce petroleum products that have values (Energy and Mineral Engineering EME, 2018). The operations and arrangements of the refining unit are affected by unit's location, desired products, and economic considerations (Business and Economic Research Advisor BERA, 2016). There are two main processes for separating crude oil into different products which are distillation, and cracking and reforming (BERA, 2016). Distillation process is heating and inserting the crude oil into a distillation column. Through this process, different products (fractions) are produced based on the rising in the temperature of the distillation column. Each product is captured individually based on its boiling temperature.

Cracking is used on the heaviest fractions to break them and produce some higher-value products from heavier fractions. It is widely used to produce gasoline and jet fuel. While reforming is used on the lighter fractions in order to produce more gasoline by inducing chemical reactions under a specific pressure to modify the hydrocarbon chain composition. The production of final petroleum products differs from one unit to another (EME, 2018). Based on the study of Chang & Lin (2006) on storage tank, the refining unit was the first most frequent unit for occupational accidents while the storage unit was the second one. Currently, the success of this unit depends on its capability to obtain and refine any available crude (Devold, 2013). Overall, the refining unit is a capital intensive high risk venture (The United Kingdom Petroleum Industry Association UKPIA, 2013).

Four members of the refining unit expressed their points of view regarding the current OHS framework in O&G industry, human error accidents and its related challenges in O&G industry in Bahrain, adapted best safety practices and the need for safety strategy in O&G industry in

Bahrain. Respondents from refining unit are referred as Interviewee 1 to Interviewee 4 in the text as their identities have been anonymised.

4.3.1.1 General Overview on OHS Framework in O&G Industry.

As the direct and indirect costs of work-related occupational accidents are considerably high, O&G industry should develop an effective management for the OHS framework to assess, plan, manage, and maintain safe and healthy working conditions. It is important to ensure that there are no breaks, gaps or conflicts within the different regulations of OHS framework and that any risen matter is addressed (United Kingdom Onshore Oil and Gas UKOOG, 2013). For instance, all the proposed regulations that ensure healthy and safe working practices within the OHS framework should be made under the Health and Safety at Work Act 1974. Interviewees indicated some important features regarding the existing OHS framework in O&G industry in Bahrain. Figure 4.2 presents the coding structure of these important features, and Figure 4.3 shows the cognitive mapping of these features including their sub-features.

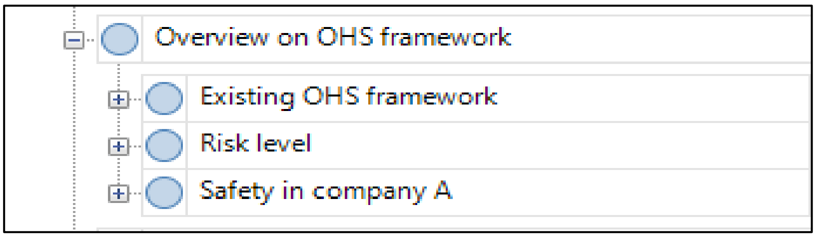

Figure 4.2: Coding Structure for OHS Framework Overview Based on the Interviewees of the Refining Unit

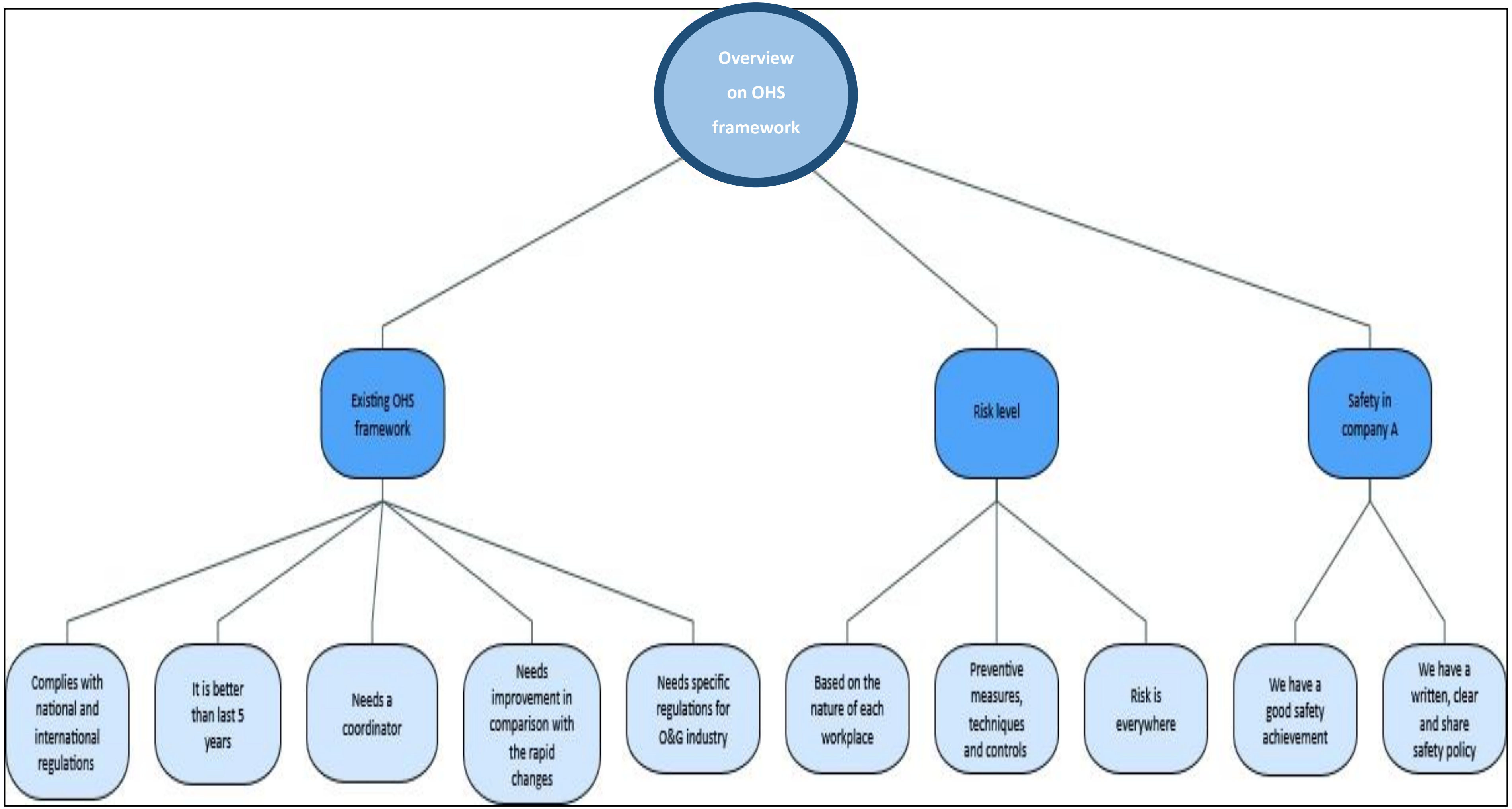

Figure 4.3: Cognitive Mapping for OHS Framework Overview Based on the Interviewees of the Refining Unit

Based on the revealed interview responses in the refining unit, interviewees described the existing OHS framework in O&G industry in Bahrain by indicating their, the risk level and the safety in their company. First, regarding their opinions on the current OHS framework, Interviewee 1 mentioned that the current one complies with the international regulations, stating, "We comply with international standards of O&G industry. Also we follow the Bahraini legislations and regulations that were developed for manufacturing sector in the country." Besides, Interviewee 2 mentioned that, "OHS framework in our company is simply a combination of international standards, Bahraini regulations, internal polices and rules. Over years, this combination integrated together and developed this OHS framework." While Interviewee 3 described this framework from another point of view, stating, "The existing OHS framework is an acceptable one in comparison to the last five years."

In addition, most of responses in the refining unit indicated that the current OHS framework needs some important improvements in comparison to the rapid changes in the workplaces. In Interviewee 1's words, "as the workplace is changing continuously, the regulations sometimes become inconsistent with these changes and need to be adjusted to be more valuable." Agreeing with this statement, Interviewee 2 stated that, "OHS framework was developed years ago while numerous alterations and modifications were introduced in the workplace based on different requirements. Therefore, we should keep our eyes on improving OHS regulations in conjunction with these alterations." Interviewee 3 endorsed this by indicating the recent largest oil discovery in Bahrain, stating, "Improving our regulations is a must especially as we will have extensive exploring, extracting and refining activities in the few coming years on the new largest source of O&G in Bahrain. Therefore, these activities will inherit many changes that should be addressed and included in OHS framework."

Moreover, most of interviewees in refining unit pointed out the importance of having dedicated regulations for O&G industry taking into consideration the particular nature of workplaces in this industry and the current market and regulatory conditions for this industry. For example, Interviewee 1 stated, "Most of the regulations in the current OHS framework in O&G industry in Bahrain are general but we need some specific regulations based on our industry." Supporting this, Interviewee 3 and Interviewee 4 also expressed similar thoughts. Likewise, all respondents agreed that O&G industry in Bahrain needs a coordinator authority to regulate all these matters and to coordinate OHS framework effectively. As such, Interviewee 1 stated, “there is no specific coordinator or authority that manages this framework as a whole. What we have for example is HSE team, NOGA and MOL but no specific one that is responsible of integrating and coordinating all these parties and their requirements.” Interviewee 2 endorsed this, stating, “OHS framework should be coordinated and controlled by multi professionals from one party.” Interviewee 3 voiced a similar statement. Interviewee 4 expressed also that “Before starting with improving the current regulations in OHS framework, O&G industry should deflect attention to establishing a special team, authority or agent that is responsible for the overall legislations and regulations in our industry. This authority should know clearly what we are doing, what is our workplace, what we require properly.”

Second, regarding the risk level, responses revealed that all respondents cited that risk is high in their workplaces in specific and in O&G industry in general and risk can appear anywhere. For example, Interviewee 2 stated, “Risk is high and it is anywhere but we do our best to identify it and reduce it.” Additionally, most of interviewees pointed out that risk level in O&G industry in Bahrain relies on the nature of each workplace. In Interviewee 1’s words, “In each workplace there are different levels of heat, noise and pressure, various types of equipment and machinery that we use to handle everyday functions, and different sets of risky materials. Therefore, level of risk is described by the conditions of each unit or workplace.” Interviewee 3 endorsed that, stating “the wide range of hazardous materials in a workplace along with the different level of temperature, pressure and noise all create different levels of risk. So we cannot assume that all workplaces are similar.” Interviewee 4 voiced a similar statement.

Interview responses also showed that half of refining unit’s respondents indicated that O&G industry in Bahrain adapts various tools, measures, techniques and controls to prevent, mitigate, reduce and control the risks and hazards. Interviewee 4 cited that, “We adapt several techniques and technologies and adapt several safety standards in order to reduce risk and control risk. Also we carry out regularly risk assessment and risk analysis in every workplace.” Finally, regarding safety in Company A, the analysis revealed that Interviewee 1 and Interviewee 2 agreed that there is a good safety achievement in the company in comparison to other Middle East countries. In this regard for example, Interviewee 1 stated, “I think we have a good safety basic in Bahrain in comparison to other countries in the Middle East. But more enhancement efforts are required to sustain and raise this level.” While Interviewee 3 and Interviewee 4 agreed that safety in Company A is represented by a clear safety policy and they indicated that this policy is a written and documented policy is shared among all workers.

4.3.1.2 Challenges Related to Human Errors Specific Accidents in O&G Industry in Bahrain

Human errors dominate most accident databases in O&G industry as discussed previously. Numerous challenges can contribute to these accidents. These challenges are related to the relationship between workers and the equipment they use, their environment, the available information and knowledge, and their communications with other stakeholders (Reason, 2000). Therefore, it is important to investigate and analyse human error accidents (Wiegmann, Faaborg, Boquet, Detwiler, Holcomb & Shappell, 2005). Accordingly, this section presents the responses of interviewees regarding human accidents in O&G industry in Bahrain. To understand these accidents clearly and to identify these challenges, the responses of interviewees were divided into four main sections which are the definition of human error accident, examples, challenges related to these accidents and recommendations to address these challenges. Figure 4.4 presents the coding structure of these sections in Nvivo 11.0, and Figure 4.5 shows the cognitive mapping of these sections along with the related responses from the refining unit.

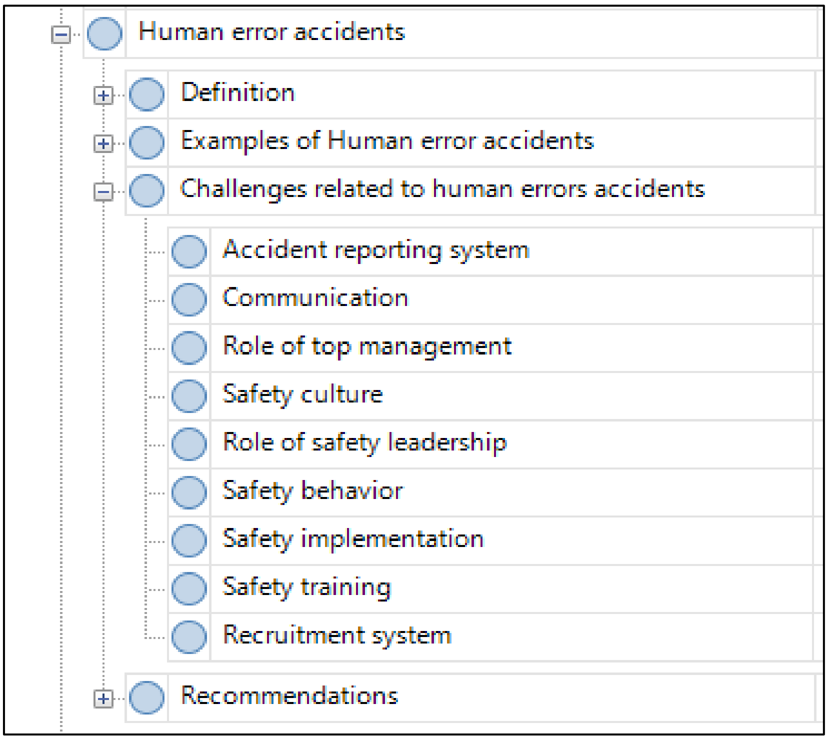

Figure 4.4: Coding Structure for Human Error Accidents Based on the Interviewees of the Refining Unit

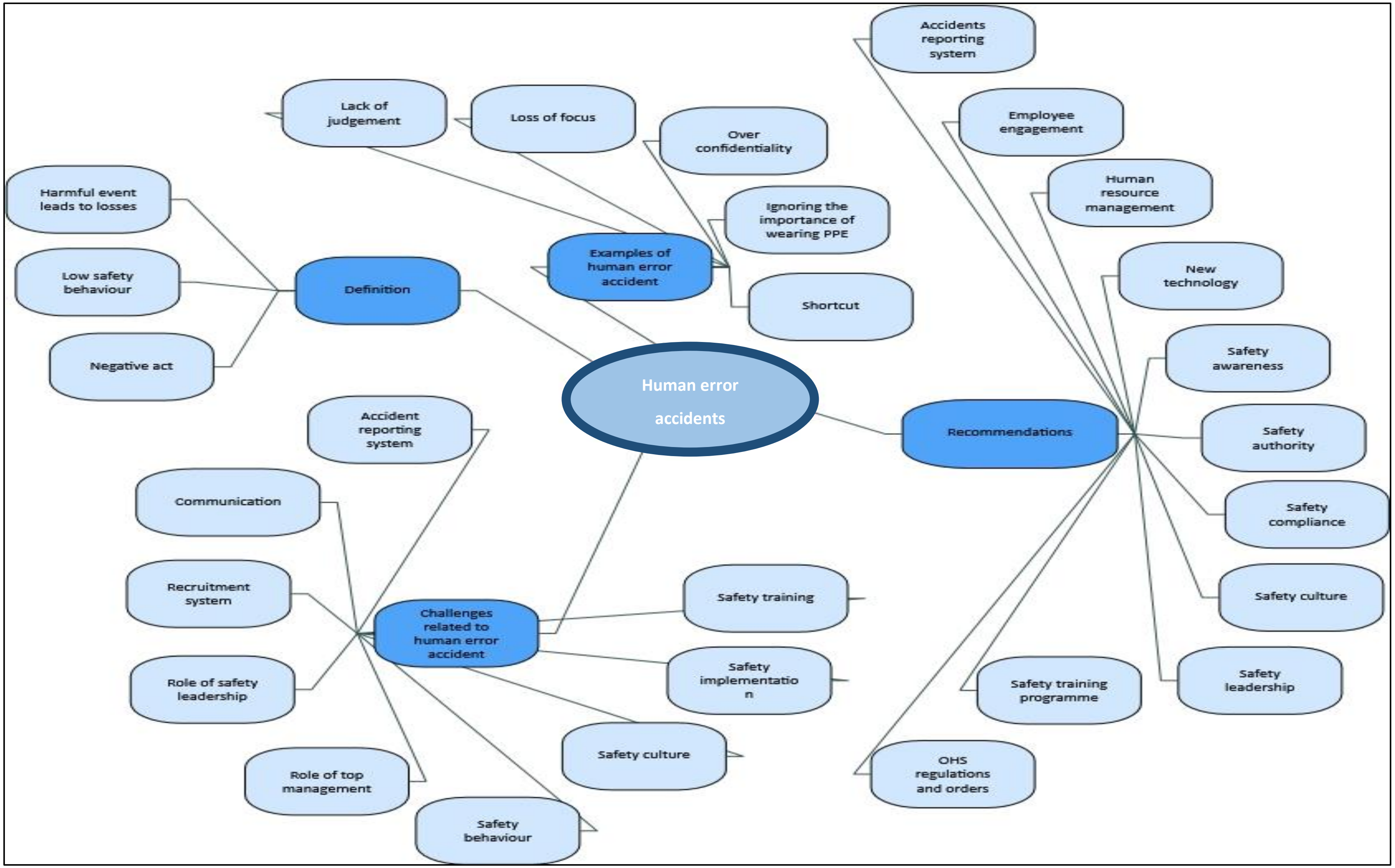

Figure 4.5: Cognitive Mapping for Human Error Accidents Based on the Interviewees of the Refining Unit

First, regarding the definition of human error accident, all responses from the managerial level of the refining unit prescribed this type of accident as a negative act or action that causes harms and different losses in the workplace. Supporting this, Interviewee 1 stated, “I can define it as negative actions of workers that lead to different losses in the overall components of workplace.” Interviewee 3 stated, “It is an error or a mistake of a worker regardless of his position that ranges between physical actions to mental decisions and plans.” All other responses in this unit expressed similar thoughts. Additionally, Interviewee 2, Interviewee 3 and Interviewee 4 asserted that human error accidents can be defined as poor safety behaviours.

Second, different examples were identified from the interviews responses within this unit. Most of responses agreed that overconfidence is the dominant example for this type of accidents. Interviewee 1 stated, “Overconfidence is a common example. It occurs simply when an employee skips or breaks some safety rules while doing a task because he is too familiar with it and he does not believe that these rules were issued for his safety first.” According to Interviewee 2, Interviewee 3 and Interviewee 4, loss of focus is another example of human error that leads to accidents. In Interviewee 2’s words, “Loss of focus while carrying out any task is a human error that leads to accidents. It happens when a worker is familiar with the task and it becomes as a routine for him, thereby; he performs it unconsciously.” Interviewee 3 also expressed a thought endorsing Interviewee 2’s statement.

In addition, results revealed that shortcut is another example of human error that leads to accidents from only the point of view of Interviewee 2. Interviewee 2 saw that shortcut happens when a worker wants to get things done faster by skipping several safety procedures. And this unfortunately may cause an unexpected accident. While from the point of view of Interviewee 1, lack of judgement is a common example of human error, stating, “Lack of judgement is another cause that we face every day with a number of employees.” Interviewee 2 and Interviewee 4 voiced similar statements. Besides, Interviewee 4 found that ignoring the importance of wearing Personal Protective Equipment (PPE) is another example. Interviewee 4 added, “Some employees forget to wear their personal protective equipment when they enter the workplace as they will just enter the workplace for few seconds to do a quick task and he will return back and nothing will happen. This is wrong no one can grantee that.” Interviewee 2 and Interviewee 3 expressed thoughts endorsing Interviewee 4’s statement.

Third, regarding the challenges related to these accidents, the analysis revealed a wide range of challenges with different agreement. Figure 4.6 visualises the hierarchy chart of the identified challenges from the viewpoints of the managerial level of the refining unit by comparing the level of agreement on each challenge.

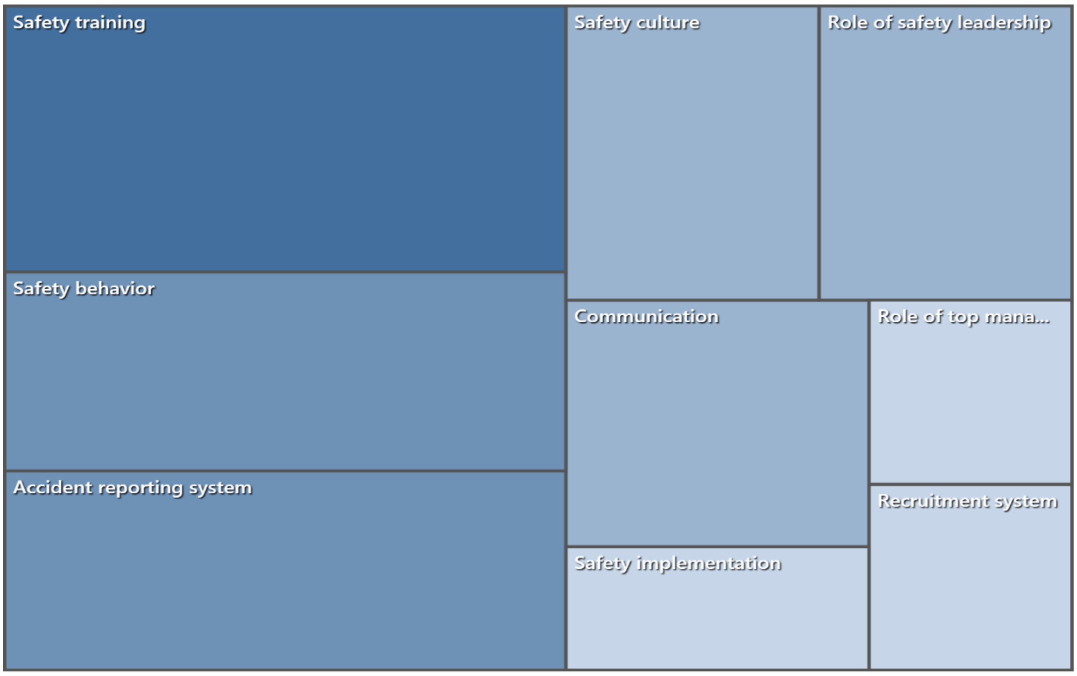

Figure 4.6: Hierarchy Chart for Challenges Related to Human Error Accidents Based on the Interviewees of the Refining Unit

Based on Figure 4.6, nine challenges were identified which are safety training, safety behaviour, accidents reporting system, safety culture, role of safety leadership, communication, safety implementation, role of top management and recruitment system. A high level of consensus was accounted for three challenges which are safety training, safety behaviour and Accidents reporting system. While a moderate level of consensus was accounted for three challenges which are safety culture, role of safety leadership and communication. Lastly, a low level of consensus was accounted for three challenges which are safety implementation, role of top management and recruitment system.

Third, at the end of this section, the respondents provided some important recommendations to tackle the above challenges in their unit. From their point of views, addressing these recommendations will greatly contribute to the reduction of human error accidents in refining unit. Figure 4.7 summarises the hierarchy chart of the collected recommendations from the viewpoints of the managerial level of the refining unit by comparing the level of agreement on each recommendation.

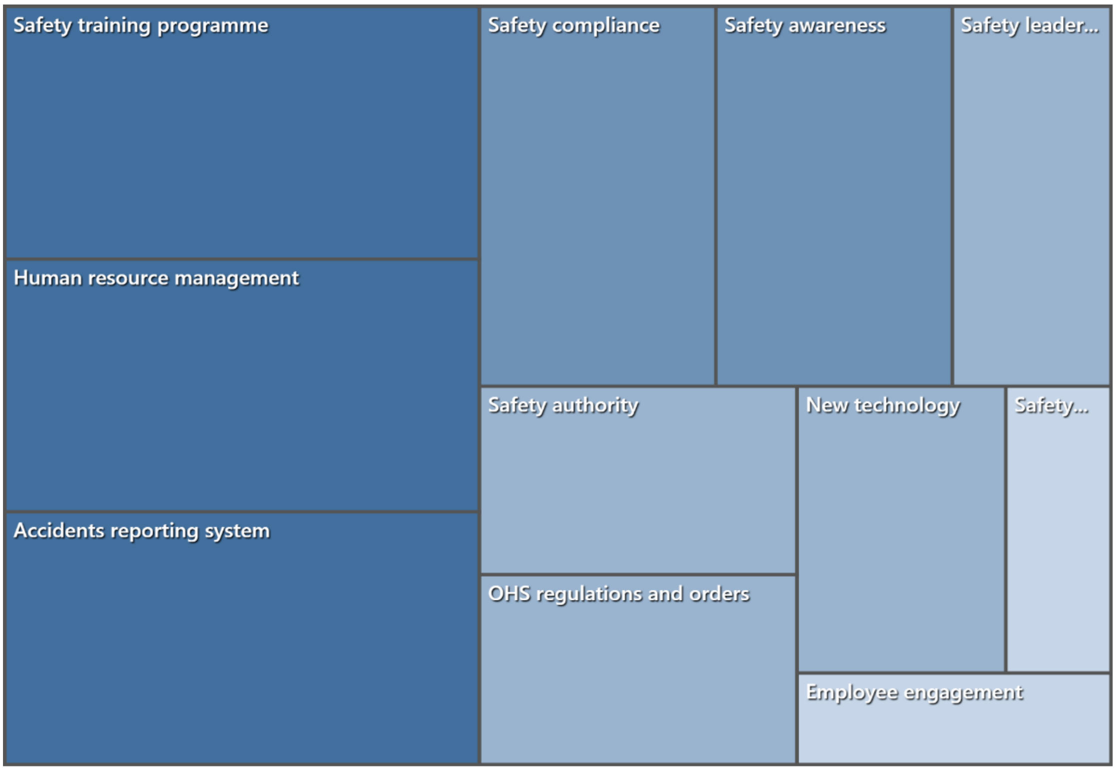

Figure 4.7: Hierarchy Chart for Recommendations to Overcomes Challenges Related to Human Error Accidents Based on the Interviewees of the Refining Unit

Based on Figure 4.7, the managerial level of the refining unit pointed out eleven recommendations that assist in overcoming the above challenges. These recommendations are regarding safety training programme, human resource management, accidents reporting system, safety compliance, safety awareness, safety authority, new technology, OHS regulations and orders, safety leadership, employee engagement and safety culture. A high level of consensus was accounted for three recommendations which are safety training programme, human resource management and accidents reporting system. While a moderate level of consensus was accounted for five recommendations which are safety compliance, safety awareness, safety authority, new technology and OHS regulations and orders. And a low level of consensus was accounted for three recommendations which are safety leadership, employee engagement and safety culture.

4.3.1.3 Adapted Best Safety practices

Adapting best practices in workplaces affords the opportunity to reach the desired outcomes using a specific technique or method that has previously proven reliable through experience and research (World Health Organisation WHO, 2017). In other words, best practices are solutions to be adapted in specific similar situations and contexts. Sharing best practices improves the knowledge on certain issue through lessons learned, provides feedbacks on adapting and performing particular strategies and activities and implements significant, continuous and effective involvements (WHO, 2012). Accordingly, this section presents the responses of interviewees regarding the adapted best safety practices in O&G industry in Bahrain. Figure 4.8 presents the coding structure of the adapted best safety practices, and Figure 4.9 shows the cognitive mapping of these best safety practices.

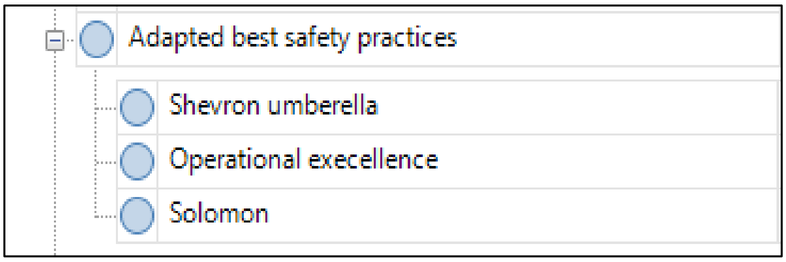

Figure 4.8: Coding Structure for the Adapted Best Safety Practices Based on the Interviewees of the Refining Unit

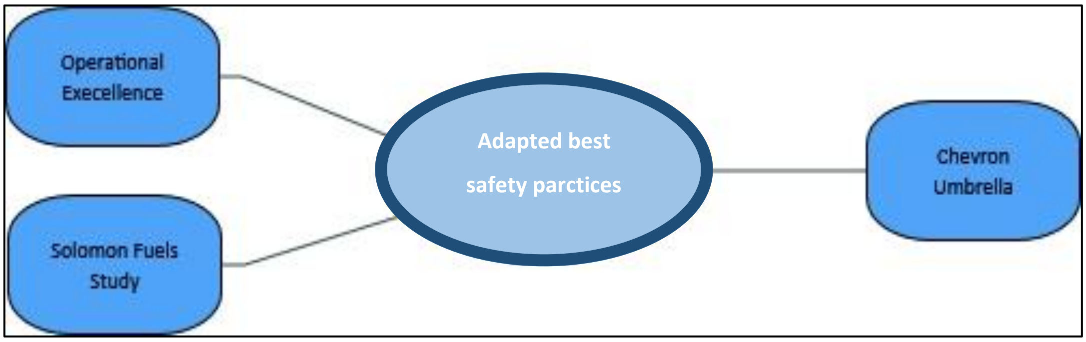

Figure 4.9: Cognitive Mapping for the Adapted Best Safety Practices Based on the Interviewees of the Refining Unit

Based on the collected responses from the refining unit, three main best safety practices are adapted in O&G industry in Bahrain which are Operational Excellence, Solomon Fuels Study and Chevron umbrella. In this regard, Interviewee 2, Interviewee 3 and Interviewee 4 agreed that Operational Excellence is adapted in this industry. For example, Interviewee 4 stated, "We adapt Operational Excellence as one common best practices around the world." While only interviewee 1 indicated that O&G industry adapts Solomon Fuels Study, stating, "We adapt Solomon's Fuels Study. It is an approach to benchmarking that offers a combination of patented methodologies and broad industry experience and provides superior understandings into the key drivers that maintain a high level of performance." Additionally, Interviewee 2 and Interviewee 3 pointed that O&G industry is under Chevron umbrella.

4.3.1.4 The Need for Safety Strategy in O&G Industry in Bahrain

Safety is a critical challenge in the workplace, because as long as it is subject to continuous improvement, adequate working conditions should be ensured all time. Thus, developing an effective safety is important. Enhancing the industrial safety strategy is all about designing a plan to ensure safety, regulate OHS, improve OHS performance, identify, reduce and control risks and hazards consistently, prevent accidents, achieve the aims and objectives and maintain production and progress in O&G industry. Accordingly, this section shows the responses of interviewees regarding the need for a safety strategy in O&G industry in Bahrain. Figure 4.10 visualises the coding structure of these responses while Figure 4.11 shows the cognitive mapping of these responses.

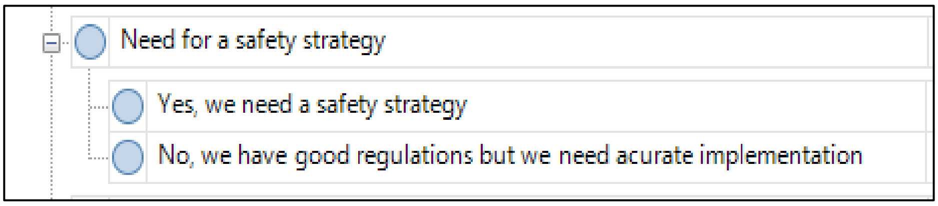

Figure 4.10: Coding Structure for the Need for a Safety Strategy Based on the Interviewees of the Refining Unit

Figure 4.11: Cognitive Mapping for the Need for a Safety Strategy Based on the Interviewees of the Refining Unit

According to the need for safety strategy, responses from the refining unit showed that Interviewee 2, Interviewee 3 and Interviewee 4 agreed that O&G industry in Bahrain needs this strategy. For instance, Interviewee 2 said, "After the last new well discovery in O&G industry in Bahrain, having a safety strategy is essential because it will help in promoting safer ways and techniques and in ensuring that the industry is moving safely towards its goals." While Interviewee 3 sated, "I think that developing a sophisticated one based on our workplace circumstances and that is developed by multi-professionals team will positively contribute to the profits and overall performance." Interviewee 4 also expressed thought endorsing Interviewee 3's statement. On the other hand, Interviewee 1 had a different point of view, stating, "We do not need a safety strategy as we have good safety standards and procedures and we have a good OHS framework even if it needs some improvements. What we need is perfectly following these legal requirements and accurately implementing the written procedures. These two points are things that we miss."

4.3.2 Case 2: Distributing Unit

Distributing unit is responsible for dispensing the end products to a variety of wholesalers and retailers through several distribution terminals like airports, gasoline stations, ports and industries (EME, 2018; Devold, 2013). The total length of the distributing unit pipelines in this unitin Bahrain is around 52 km. Within this unit, the end products or marketable products are loaded onto trucks or ships to the Middle East, India, the Far East, South East Asia and Africa. Examples of these products are Liquefied Petroleum Gas, Naphtha, Gasoline, Kerosene, Diesel, Lube Base Oil, Fuel and Asphalt (Bapco, 2013). This unit is one of the high-risk area because it tends to compress some fractions that cannot be compressed easily into small volumes (Devold, 2013).

Four members of the distributing unit expressed their points of view regarding the current OHS framework in O&G industry, human error accidents and its related challenges in O&G industry in Bahrain, adapted best safety practices and the need for safety strategy in O&G industry in Bahrain. Respondents from distributing unit are referred as Interviewee 5 to Interviewee 8 in the text as their identities have been anonymised.

4.3.2.1 General Overview on OHS Framework in O&G Industry

Figure 4.12 presents the coding structure of these important features, and Figure 4.13 shows the cognitive mapping of these features including their sub-features.

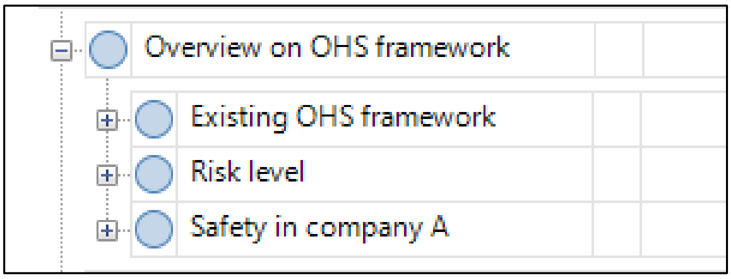

Figure 4.12: Coding Structure for OHS Framework Overview Based on the Interviewees of the Distributing Unit

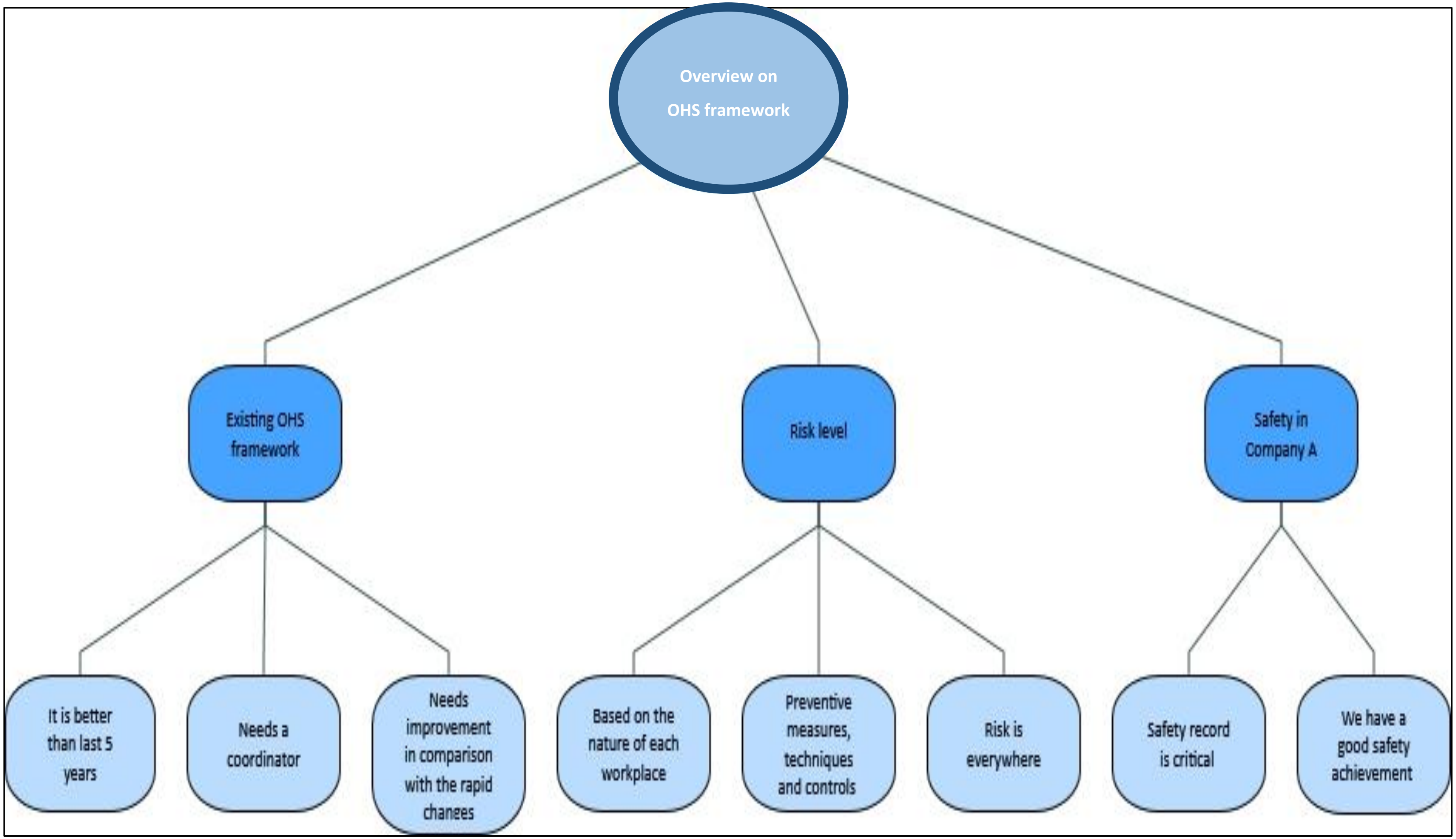

Figure 4.13: Cognitive Mapping for OHS Framework Overview Based on the Interviewees of the Distributing Unit

Based on the interviews responses in the distributing unit, interviewees described the OHS framework in O&G industry in Bahrain by indicating their opinions regarding the current one, the risk level and the safety in their company. First, regarding their opinions on the existing OHS framework, Interviewee 5, Interviewee 7 and Interviewee 8 confirmed that the current OHS framework is better than the last five years. In Interviewee 5's words, "The existing OHS framework is meanwhile better than the last five years but I cannot say that it is perfect." Furthermore, Interviewee 5, Interviewee 6 and Interviewee 7 pointed out that this framework needs a continuous improvement to align with rapid changes in the workplace. Interviewee 6 added, "The existing OHS framework needs more improvement to address the gaps that we see it in our daily supervision which are created from the dynamic market, globalisation pursuer and legal requirement."

In addition, Interviewee 7 and Interviewee 8 agreed that O&G industry in Bahrain needs a coordinator authority to effectively regulate and coordinate all these changes and OHS framework. As such, Interviewee 7 stated, "O&G industry in Bahrain needs a specific highly qualified team or authority who is able to study the market requirements, OHS requirement and the new improvement in order to improve the current OHS framework appropriately." Interviewee 8 endorsed this, stating, "This legal body or authority is responsible to coordinate and control OHS framework. And this cannot be achieved unless there are regular internal and external communication and meetings with Ministry of labour and the HSE committee within all companies in O&G industry." This thought indicated that the success of this authority depends on its internal and external communications.

Second, regarding the risk level, responses revealed that all respondents agreed that risk is high and risk can appear anywhere in O&G industry. Supporting this, Interviewee 7 stated, "Risk is high in our industry as we have bad weather, heavy equipment, risky material, high pressure and many other things." Moreover, Interviewee 5, Interviewee 6 and Interviewee 7 cited that this level is a result of the nature of each workplace in term of task, material, equipment or other components. Interviewee 6, for example, said, "I believe that based on the nature of each workplace, and level of complexity of this workplace we can assess this level of risk. We have to invest, assess and control regularly and continuously." In this accordance, Interviewee 5, Interviewee 6 and Interviewee 8 voiced similar statements that various tools, measures, techniques technologies and controls are used in O&G industry in

Bahrain to prevent and control the risks and hazards. Interviewee 8 cited that, “We conduct a regular risk assessment in the workplace and we adapt many technologies to decrease the level of risk.”

Finally, regarding safety in Company A, results revealed that half of interviewees of the distributing unit agreed that there is a good safety achievement in the company in comparison to other Middle East countries. In this regard for example, Interviewee 5 stated, “Based on the available published statistics in our company, our safety achievement is better than other companies in the same region.” Additionally, Interviewee 6, Interviewee 7 and Interviewee 8 confirmed that safety in Company A is a critical record. As such, Interviewee 7 added, “Safety data in our company is an issue that all should be aware about it. This means that we should increase it and reduce any potential mistake that could cost us a lot.” Likewise, Interviewee 8 cited, “Although no company is perfect and challenges are everywhere in O&G industry, having a good safety data is too important.”

4.3.2.2 Challenges Related to Human Errors Specific Accidents in O&G Industry in Bahrain.

Figure 4.14 presents the coding structure of these sections in Nvivo 11.0, and Figure 4.15 shows the cognitive mapping of these sections along with the related responses.

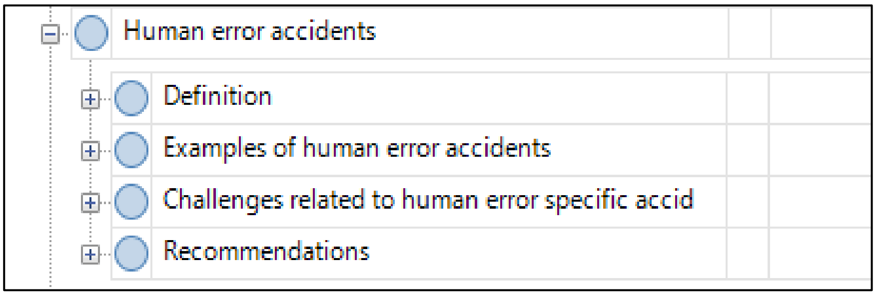

Figure 4.14: Coding Structure for Human Error Accidents Based on the Interviewees of the Distributing Unit

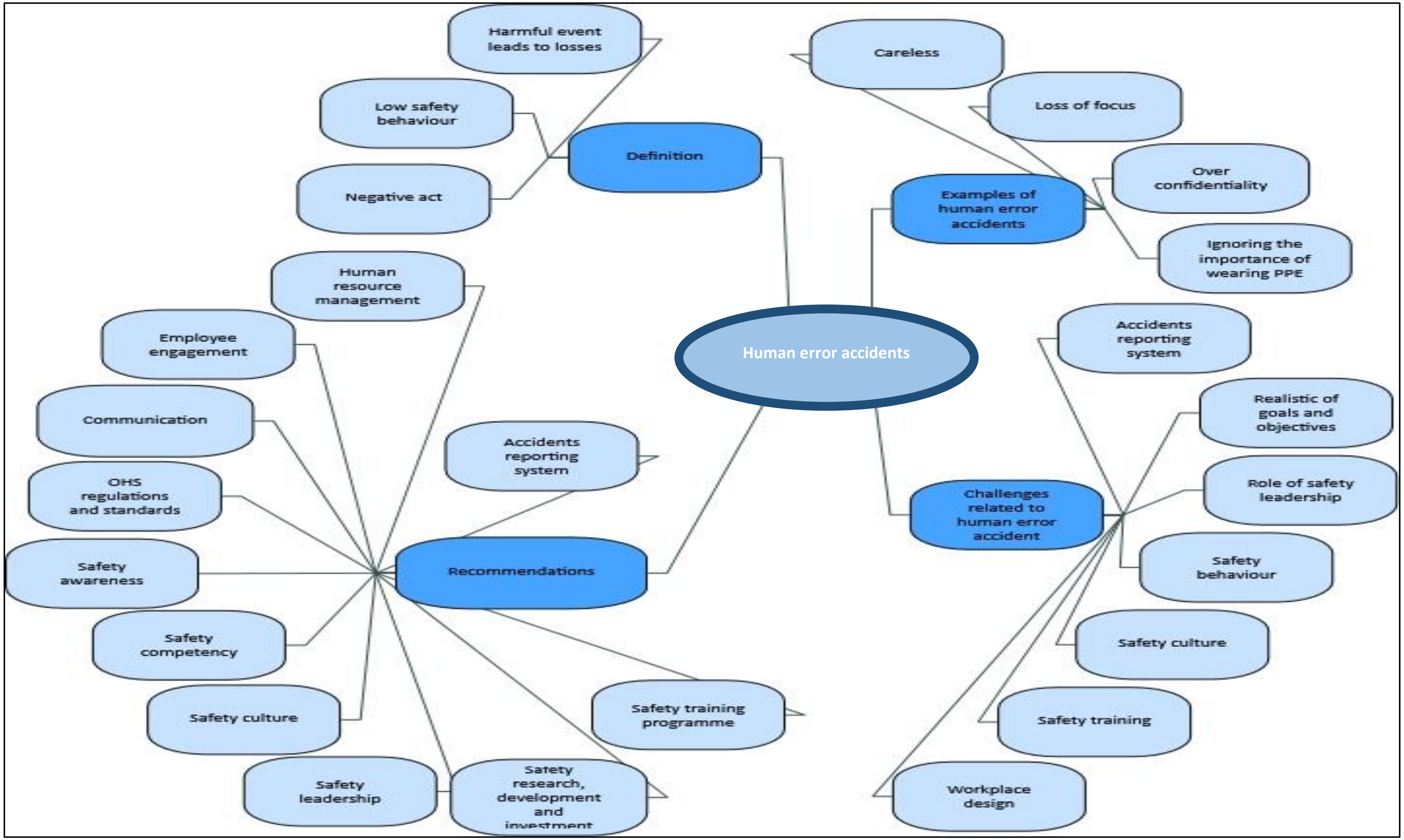

Figure 4.15: Cognitive Mapping for Human Error Accidents Based on the Interviewees of the Distributing Unit

First, regarding the definition of human error accident, all responses from the managerial level of the distributing unit indicated that approximately 80% of accidents in O&G industry are due to human error. As such, interviewee 5 stated, “First, I can tell you that accidents caused by human are around 80% of all accidents while the remaining percentage is for process and equipment failure.” All responses of this unit prescribed this type of accident as a negative act or action done by workers in workplaces. Supporting this, Interviewee 6 stated, “At any point, any worker can execute any simple or complex task wrongly and unfortunately this will lead to an accident. Sometimes, a small action can lead to a large accident.” Interviewee 7 and Interviewee 8 expressed similar thoughts. Additionally, Interviewee 5, Interviewee 7 and Interviewee 8 asserted that human error accident is a harmful event that creates different types of loss in the workplace, industry and the society. Interviewee 7 stated, “These accidents resulted in loss in workers, equipment, plant and the surrounded environment.” Moreover, only Interviewee 8 referred human error accident to a poor safety behaviour, stating, “This type of accident is considered as a poor safety behaviour.”

Second, different examples were identified from the interviews responses of the distributing unit. Most of responses agreed that overconfidence is a common example for this type of accidents. Supporting that, Interviewee 5 stated, “I can say that overconfidence is behind a big portion of human error accidents.” While interviewee 7 added, “Within our complex workplace some workers do not follow the proposed procedures for a routine task under the wrong belief that I know how to perform it easily or I know how to complete it quickly. This is the case of overconfidence.” Interviewee 8 voiced a similar interpretation. According to Interviewee 5, Interviewee 6 and Interviewee 8, loss of focus is another example of human error that leads to accidents. In Interviewee 6’s words, “Loss of focus is an example for human error accident. The scenario of loss of focus happens when equipment, system, technology and rules are all well-placed but a worker is handling a task unconsciously.” Interviewee 8 also expressed a thought endorsing Interviewee 6’s statement by indicating that within this situation, a worker has a low sensibility and safety responsibility and this may create an accident in the workplace.

In addition, results revealed that carelessness is another example of human error that leads to accidents from only the point of view of Interviewee 5 and Interviewee 8. They saw that carelessness happens when a worker is working unconscientiously and making unintended errors because performed the work/task in an impulsive or in a hurried manner. Furthermore, from the point of view of Interviewee 5, Interviewee 7 and Interviewee 8, ignoring the importance of wearing PPE is another example for that. In Interviewee 8's words, "Human error is commonly the situation when a worker is not wearing PPE while they are dealing with the hazardous material."

Third, regarding the challenges related to these accidents, the responses revealed a wide range of challenges with different agreement. Figure 4.16 visualises the hierarchy chart of the identified challenges from the viewpoints of the managerial level of the distributing unit by comparing the level of agreement on each challenge.

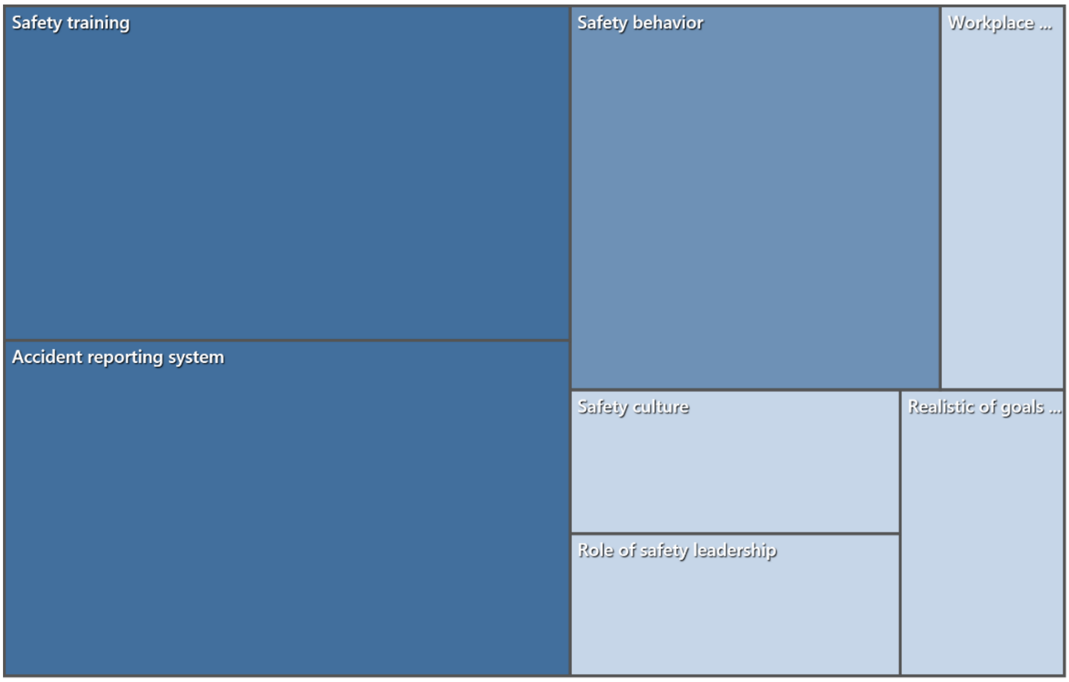

Figure 4.16: Hierarchy Chart for Challenges Related to Human Error Accidents Based on the Interviewees of the Distributing Unit

Based on Figure 4.16, seven challenges were identified which are accidents reporting system, safety training, safety behaviour, safety culture, role of safety leadership, realistic of goals and objectives and workplace design. A high level of consensus was accounted for two challenges which are safety training and accidents reporting system. While a moderate level of consensus was accounted for one challenge which is safety behaviour. And a low level of consensus was accounted for four challenges which are safety culture, role of safety leadership, realistic of goals and objectives and workplace design.

Third, at the end of this section, the respondents provided several essential recommendations to overcome the above challenges in their unit. From their point of views, addressing these recommendations will reduce the potential of human error accidents in distributing unit. Figure 4.17 summarises the hierarchy chart of the collected recommendations from the viewpoints of the managerial level of the distributing unit by comparing the level of agreement on each recommendation.

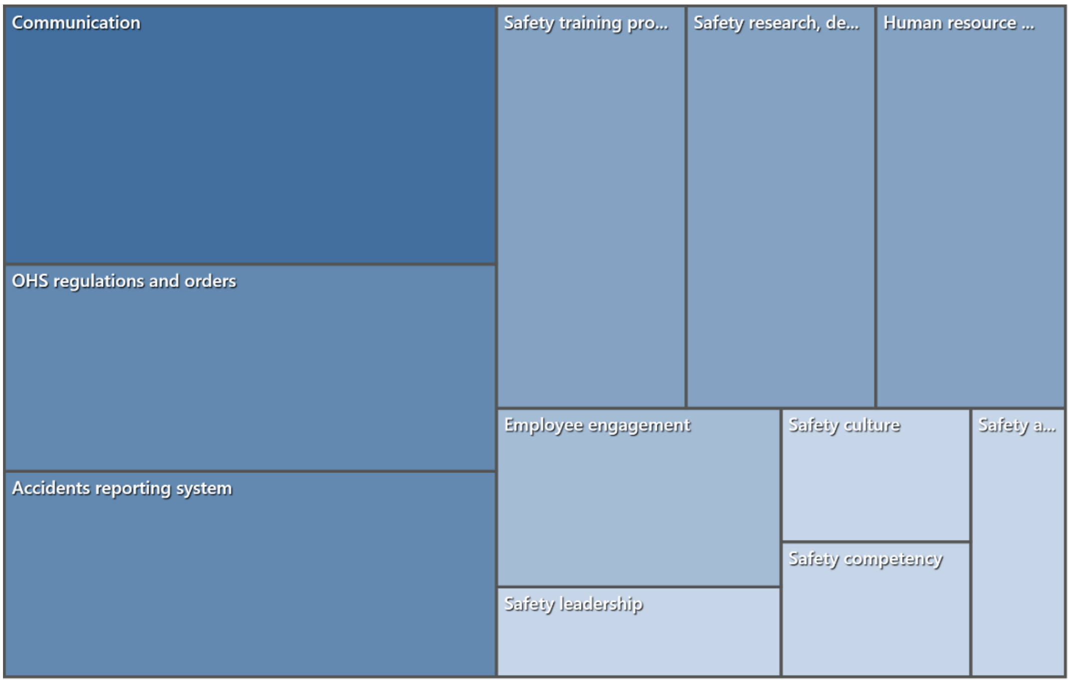

Figure 4.17: Hierarchy Chart for Recommendations to Overcome the Challenges Related to Human Error Accidents Based on the Interviewees of the Distributing Unit

Based on Figure 4.17, the managerial level of the distributing unit pointed out eleven recommendations that should be taken into consideration to overcome the previous challenges. These recommendations are regarding communication, OHS regulations and orders, accidents reporting system, safety training programme, safety research, development and investment, human resource management, employee engagement, safety culture, safety leadership, safety competency and safety awareness. A high level of consensus was accounted for three recommendations which are communication, OHS regulations and orders and accidents reporting system. While a moderate level of consensus was accounted for four recommendations which are safety training programme, safety research, development and investment, human resource management and employee engagement. In addition, a low level of consensus was accounted for four recommendations which are safety culture, safety leadership, safety competency and safety awareness.

4.3.2.3 Adapted Best Safety practices

Figure 4.18 presents the coding structure of the adapted best safety practices, and Figure 4.19 shows the cognitive mapping of these best safety practices.

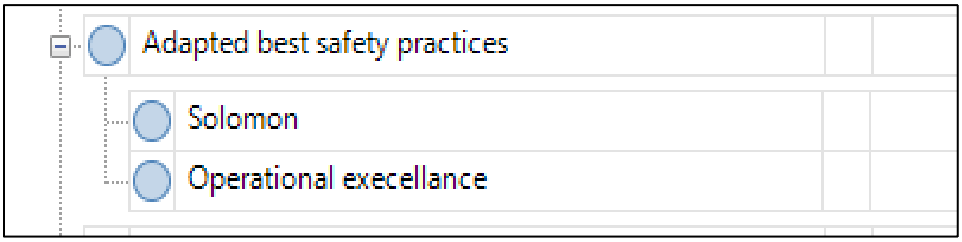

Figure 4.18: Coding Structure for the Adapted Best Safety Practices Based on the Interviewees of the Distributing Unit

Figure 4.19: Cognitive Mapping for the Adapted Best Safety Practices Based on the Interviewees of the Distributing Unit

Based on the collected interviews responses from the distributing unit, two main best safety practices are adapted in O&G industry in Bahrain which are Operational Excellence and Solomon Fuels Study. In this regard, Interviewee 5, Interviewee 6 and Interviewee 8 agreed that Operational Excellence is adapted in this industry. For example, Interviewee 5 stated, "We comply with different international standards and we follow several safety best practices like Operational Excellence and Solomon's Fuels Study." Additionally, interviewee 5, Interviewee 6 and Interviewee 7 indicated that O&G industry adapts Solomon Fuels Study. For example, Interviewee 6 expressed that, "We adapt Solomon's Fuels Study in order to maintain a high level of performance by providing valuable information and indicating the areas that boost the level of performance in the workplace."

4.3.2.4 The Need for Safety Strategy in O&G Industry in Bahrain

Figure 4.20 visualises the coding structure of these responses while Figure 4.21 shows the cognitive mapping of these responses.

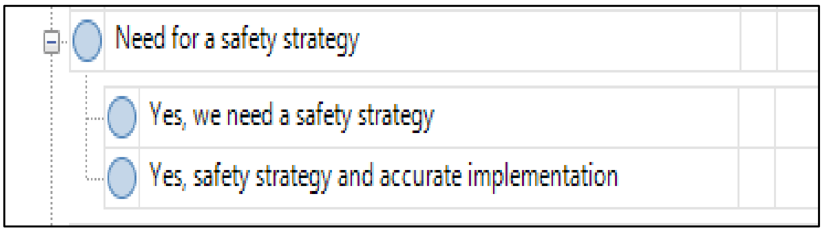

Figure 4.20: Coding Structure for the Need for a Safety Strategy Based on the Interviewees of the Distributing Unit

Figure 4.21: Cognitive Mapping for the Need for a Safety Strategy Based on the Interviewees of the Distributing Unit

According to the need for safety strategy, all the responses of the managerial level of the distributing unit agreed that O&G industry in Bahrain needs to build a safety strategy. In Interviewee 5's words, "Currently, O&G industry does not have a specific safety strategy but in the coming few years we must have it for better control and for a clear vision for achieving our goals." This was affirmed by Interviewee 6 who said, "The current OHS framework is not enough, we should develop a specific safety strategy that focuses on our industry and safety in our area and formulates rules consistent with our situation, policy, management of change and corporate strategy. As well as, this strategy should promote an updated learning curve and apply key performance indicators method in order to show the needs and concerns simultaneously."

On top of that, Interviewee 7 endorsed this by stressing the importance of not just building this strategy but also the importance of accurate implementation for this strategy, stating, "The issue in my opinion is not just a need for a safety strategy rather we need an accurate implementation for it. Because having a perfect safety strategy without accurate implementation is a failure." Interviewee 8 voiced a similar thought Interviewee 7. In line with that, Interviewee 8 indicated another important point, stating, "This safety strategy should learn all to speak the same language regarding safety and all should be responsible for effective implementation not just the HSE committee. Safety strategy is a journey with no destination." This statement highlights the importance of employee's safety responsibility.

4.3.3 Case 3: Storage Unit

Storage unit is the final stage before O&G leaveing the platform after the refining processes (Devold, 2013). This unit is where the end products are stored for distribution or emergency reserves. The storage unit in O&G industry in Bahrain composes of 170 storage tankers at various sites with a total capacity of more than 14 million barrels (Bapco, 2013). Storage unit is considered as a high-risk unit because some products like hydrogen cannot easily be compressed to small volumes and these products require quite huge gas storage tanks. Additionally, it requires adequate measures to estimate how many tankers are required and on which routes these products will be transmitted (BERA, 2016). The failure of the estimation is associated with considerable costs. However, the storage unit is a very complex system that is subjected to stringent inspections, rigorous regulations and compliance, HSE concerns, adequate constructions and maintenance of tankers and the selection of qualified crew and personnel (BERA, 2016). Based on the study of Chang & Lin (2006) on storage tank, the refining unit was the first most frequent unit for occupational accidents while the storage unit was the second one.

Four members of the storage unit expressed their points of view regarding the current OHS framework in O&G industry, human error accidents and its related challenges in O&G industry in Bahrain, adapted best safety practices and the need for safety strategy in O&G industry in Bahrain. Respondents from storage unit are referred as Interviewee 9 to Interviewee 12 in the text as their identities have been anonymised.

4.3.3.1 General Overview on OHS Framework in O&G Industry.

Figure 4.22 presents the coding structure of these important features, and Figure 4.23 shows the cognitive mapping of these features including their sub-features.

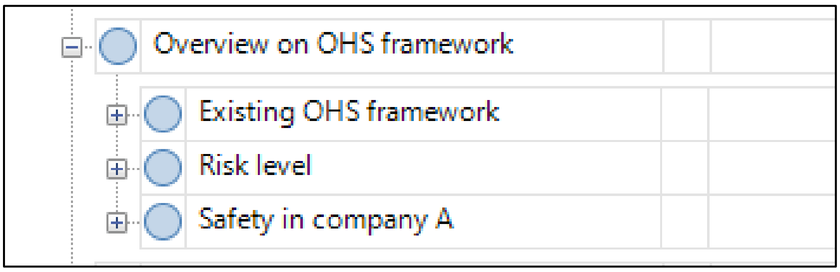

Figure 4.22: Coding Structure for OHS Framework Overview Based on the Interviewees of the Storage Unit

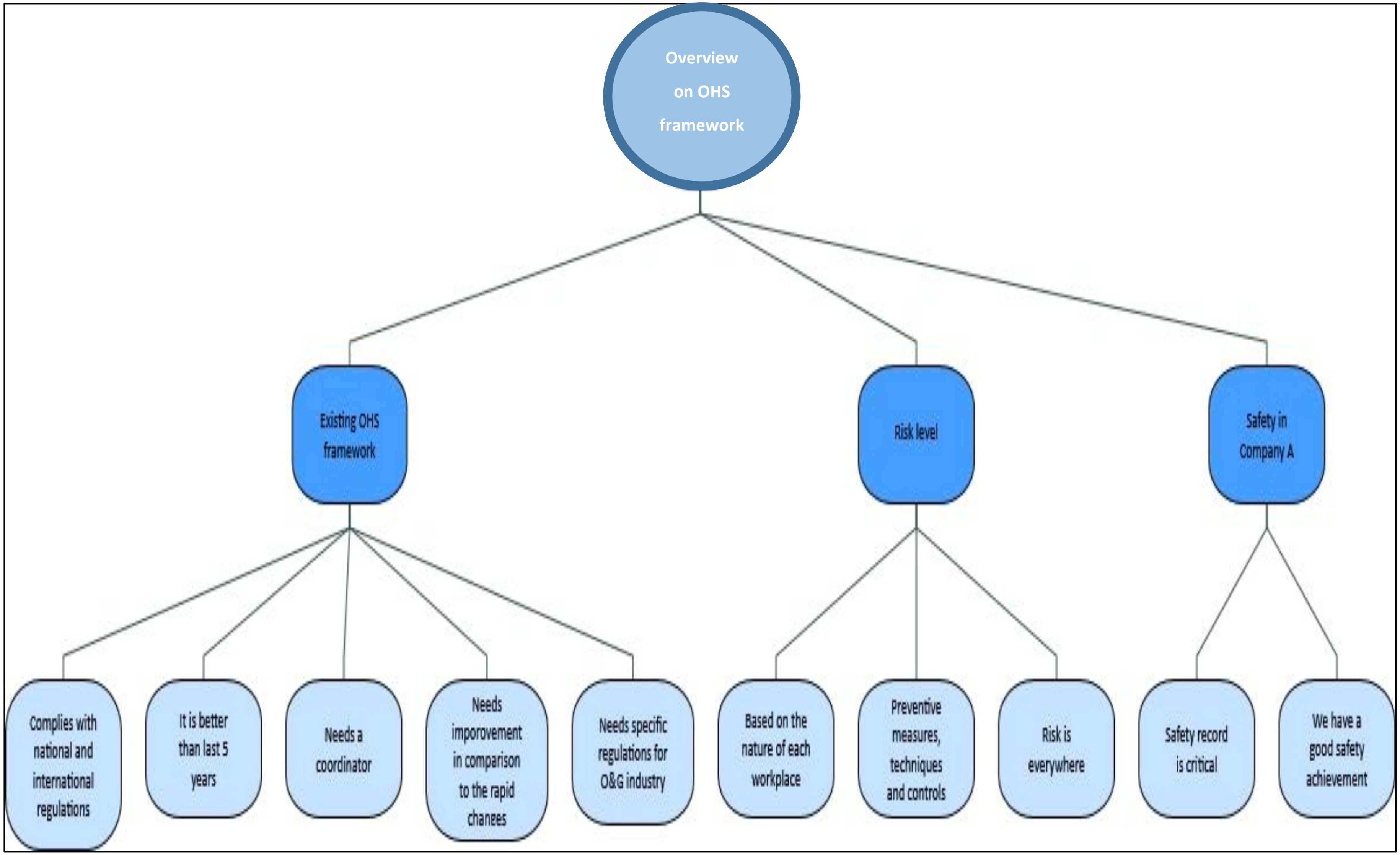

Figure 4.23: Cognitive Mapping for OHS Framework Overview Based on the Interviewees of the Storage Unit

Based on the results of interviews responses of the storage unit, interviewees described the OHS framework in O&G industry in Bahrain by indicating their opinions regarding the current one, the risk level and the safety in their company. First of all, regarding their opinions on the existing OHS framework, Interviewee 9, Interviewee 11 and Interviewee 12 confirmed that the current OHS framework complies with the national and international regulations. For instance, Interviewee 9 added, “Our OHS framework complies with international regulatory requirement and also complies with the internal regulations in Bahrain.” Additionally, Interviewee 11 indicated that the current OHS framework is better than the last five years.

On the other hand, other responses pointed out that the current OHS framework needs several enhancement points that should be addressed. For example, Interviewee 10 and Interviewee 12 described the need for a coordinator to regulate this framework and add more required enhancements. In Interviewee 10’s words, “We need a big step to create an O&G authority or team who is responsible for coordinating and issuing legislations and regulations particularly for O&G industry.” While Interviewee 12 described this need by focusing on the importance of considering the qualifications of the members of this authority. Based on that, highly qualified members should be appointed in this authority. Furthermore, Interviewee 9, Interviewee 10 and Interviewee 11 pointed out also another need for OHS framework which is the need for continuous improvements to align with the different changes in the workplace. Interviewee 9 added, “As there are variety challenges in the industry, this means that the existing OHS framework should be improved and changed to overcome these challenges and fill the gaps.” Interviewee 12 endorsed that, stating, “The international regulatory requirement for this industry is changing rapidly and sometimes we are not as fast as other countries in complying with these requirements. Thus, I think we need to do more for our OHS framework to keep it consistent with the international one.” Interviewee 9 indicated also the need for dedicated regulations for O&G industry taking into consideration the particular nature of workplaces in this industry, stating, “There is a lack of industry’s specific nature regulations that concern on the specific circumstances of our O&G industry.”

Second, regarding the risk level, analysis revealed that all respondents of storage unit confirmed that risk is high and it is anywhere in O&G industry. Supporting this, interviewee 11 stated, “Risk in O&G industry is anywhere as long as we are working with chemical material, high temperature, high pressure and high noise.” Other interviewees in this unit voiced similar statements. Moreover, Interviewee 11 and Interviewee 12 agreed that the level of risk in each workplace is different based on the overall nature, structure and components of this workplace. Interviewee 12, for example, said, "Based on the setting of the workplace, different hazards have been spotted and for each type we apply several prevention and control techniques to control them." In addition, most of interviewees confirmed that various tools and techniques are used in O&G industry in Bahrain to prevent and reduce the risks and hazards. In this unit also most of responses focused on risk analysis and risk assessment as adequate preventive tools in their unit. For example, interviewee 9 stated, "We apply risk analysis and risk assessment for storage tankers.''

Finally, regarding safety in Company A, responses revealed that most of Interviewees of the storage unit agreed that there is a good safety achievement in the company in comparison to other Middle East countries. In this regard for example, Interviewee 10 stated, "Sometime safety records go up and sometime it go down but in general it is better than other Middle East countries. Even though we are trying to push it up all time." Additionally, Interviewee 11, noted that safety in Company A is a critical record, stating, "Safety data in our company is an important record in which we assess, control, comply and communicate to increase it because any accident in our industry will be very costly."

4.3.3.2 Challenges Related to Human Errors Specific Accidents in O&G Industry in Bahrain

Figure 4.24 presents the coding structure of these sections in Nvivo 11.0, and Figure 4.25 shows the cognitive mapping of these sections along with the related responses.

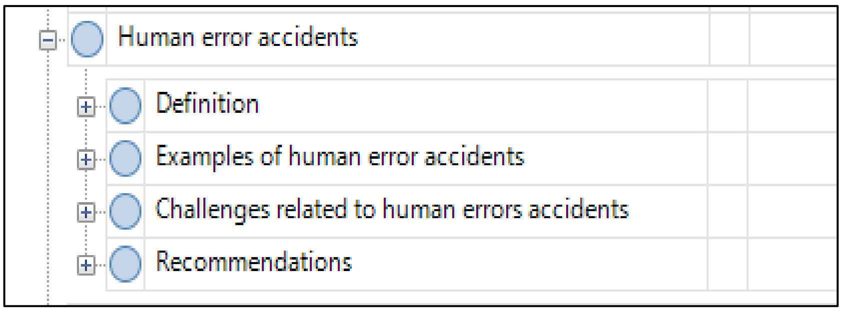

Figure 4.24: Coding Structure for Human Error Accidents Based on the Interviewees of the Storage Unit

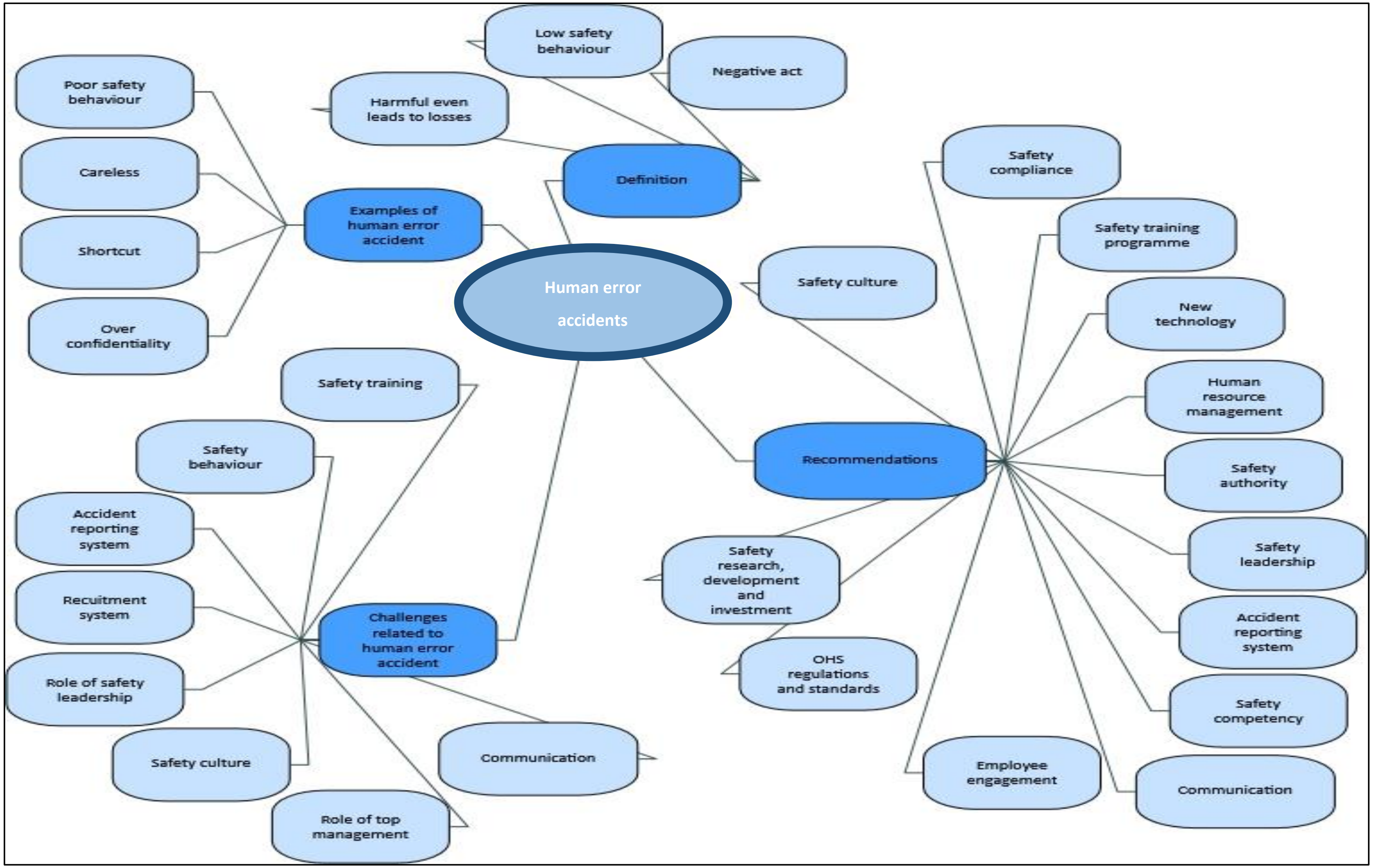

Figure 4.25: Cognitive Mapping for Human Error Accidents Based on the Interviewees of the Storage Unit

First, regarding the definition of human error accident, all responses from the managerial level of the storage unit indicated that human error was the cause of 80% of accidents in the workplaces in O&G industry. As such, interviewee 10 stated, “Based on my experience in this industry, 80% of the accidents occurred in this industry due to human errors and the remaining percentage was for other causes.” All responses of storage unit cited that this type of accident is a mistake or wrong/negative act/action. Supporting this, Interviewee 12 stated, “It occurred when a worker do unintentionally an action that has a negative impact on the overall industry during the fulfilment of any task.” Other Interviewees expressed similar thoughts. In this regard, Interviewee 9 stated, “human error is a deviation of not following the standards and the work process accurately while dealing with dangerous items.” Additionally, all interviewees in this unit agreed that human error accident is a harmful event that creates several bad consequences on the worker, plant and the society. For instance, Interviewee 11 stated, “Human error accident is simply forgetting, skipping and eliminating any rule or procedure in the workplace and this creates a big loss in the company, industry, staff, equipment, and environment.” Moreover, Interviewee 10 and Interviewee 11 asserted that human error accident can be a form of poor safety behaviour. For example, Interviewee 10 stated, “This negative act represents a low safety behaviour of a worker.”

Second, different examples were identified from the interviews responses within storage unit. Most of respondents agreed that overconfidence is the first top example for this type of accidents. Supporting that, Interviewee 9 stated, “The first example is overconfidence when the systematic procedures for a task are not followed and the worker depends on his own experience as he does this work routinely. Mostly these accidents occurred during the shutdown time because there is high stress, work overload and long working hours.” While interviewee 10 added, “The common scenario is overconfidence. When an employee skips some safety rules while doing a task because he is too familiar with it. This is a big problem that we face.” Interviewee 11 voiced a similar interpretation. According to Interviewee 10, Interviewee 11 and Interviewee 12, carelessness is another example of human error that leads to accidents. In Interviewee 12’s words, “Carelessness is another frequent example for human error accident.”

Additionally, Interviewee 9, Interviewee 11 and Interviewee 12 agreed that shortcut is also an example in their unit. Interviewee 11 endorsed that, stating, “Shortcut is another frequent example for human error accident. Although shortcut can increase productivity, reduce repetitive stress, and help in keep workers focused in other workplaces but this is not the case in O&G industry because it can lead to severe accidents.” While in Interviewee 12’s words, “Shortcut occurs typically when a worker has both the knowledge and the control of unsafe action or condition but he consciously prefers to complete the action or overlooks the condition at risk in order to save time and/or effort.” Finally, Interviewee 10, Interviewee 11 and Interviewee 12 confirmed that ignoring the importance of wearing PPE in the workplace is an important example as well.

Third, regarding the challenges related to these accidents, different challenges were collected form the interviews responses in this unit. Figure 4.26 visualises the hierarchy chart of the identified challenges from the viewpoints of the managerial level of the storage unit by comparing the level of agreement on each challenge.

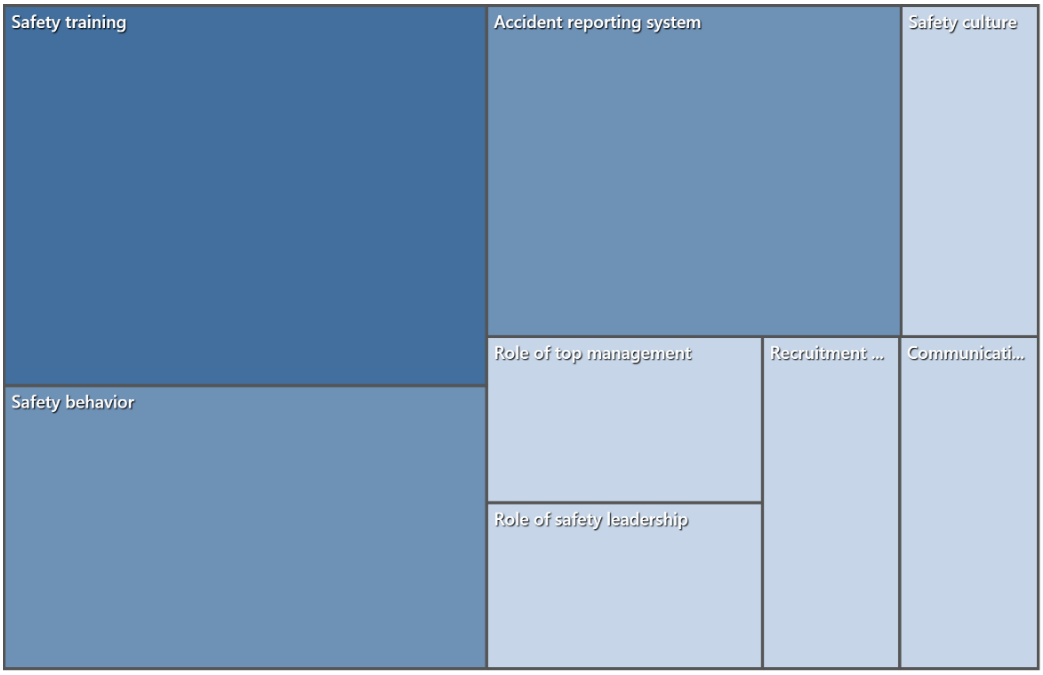

Figure 4.26: Hierarchy Chart for Challenges Related to Human Error Accidents Based on the Interviewees of the Storage Unit

Based on Figure 4.26, eight challenges were identified which are safety training, safety behaviour, accidents reporting system, role of safety leadership, role of top management, recruitment system, safety culture and communication. A high level of consensus was accounted for three challenges which are safety training, safety behaviour, and accidents reporting system. While a low level of consensus was accounted for five challenges which are role of safety leadership, role of top management, recruitment system, safety culture and communication.

Third, at the end of this section, the respondents provided important recommendations to overcome the above challenges in the storage unit. From their point of views, addressing these recommendations will reduce the potential of human error accidents in this unit. Figure 4.27 summarises the hierarchy chart of the collected recommendations from the viewpoints of the managerial level of the storage unit by comparing the level of agreement on each recommendation.

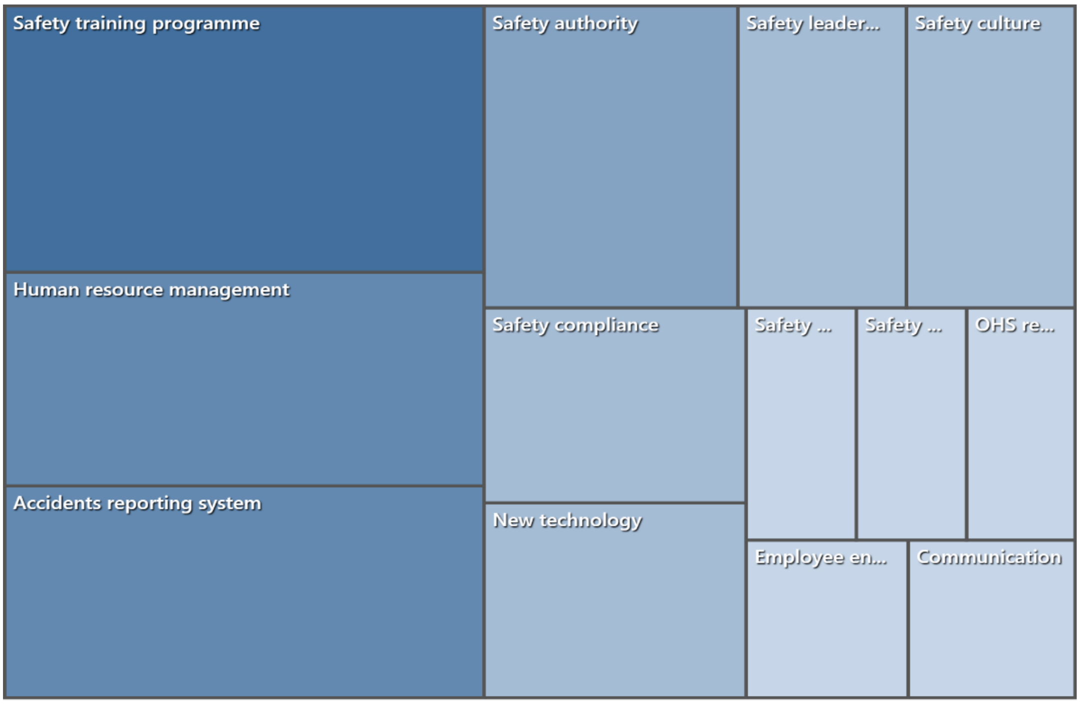

Figure 4.27: Hierarchy Chart for Recommendations to Overcome Challenges Related to Human Error Accidents Based on the Interviewees of the Storage Unit

Based on Figure 4.27, the managerial level of the storage unit pointed out thirteen recommendations that should be taken into consideration to overcome the previous challenges. These recommendation are regarding safety training programme, human resource management, accidents reporting system, safety authority, safety compliance, new technology, safety leadership, safety culture, safety competency, safety research, development and investment, OHS regulations and orders, employee engagement and communication. A high level of consensus was accounted for three recommendations which are safety training programme, human resource management and accidents reporting system. While a moderate level of consensus was accounted for five recommendations which are safety authority, safety compliance, new technology, safety leadership and safety culture. And a low level of consensus was accounted for five recommendations which are safety competency, safety research, development and investment, OHS regulations and orders, employee engagement and communication.

4.3.3.3 Adapted Best Safety practices

Figure 4.28 presents the coding structure of the adapted best safety practices, and Figure 4.29 shows the cognitive mapping of these best safety practices.

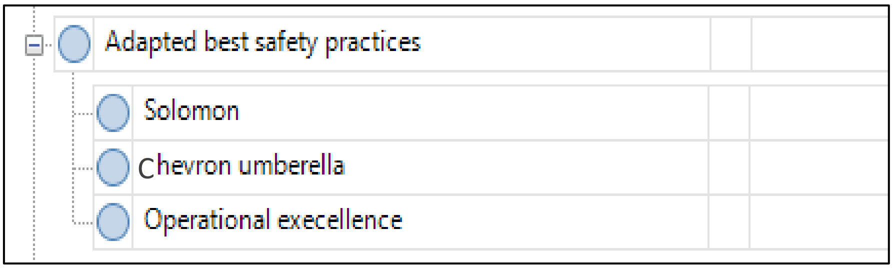

Figure 4.28: Coding Structure for the Adapted Best Safety Practices Based on the Interviewees of the Storage Unit

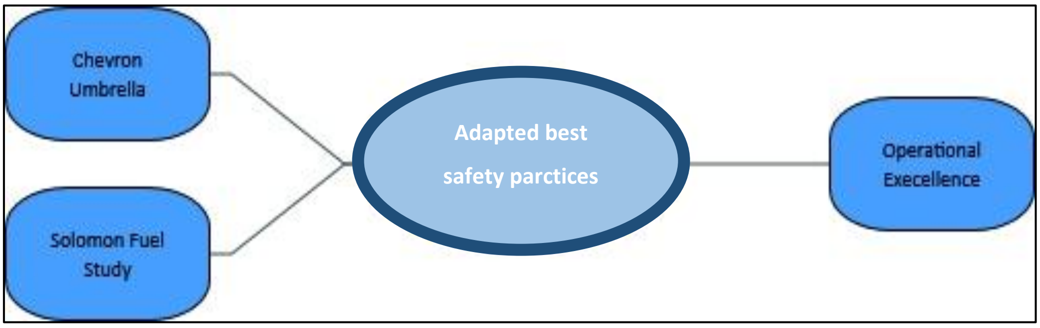

Figure 4.29: Cognitive Mapping for the Adapted Best Safety Practices Based on the Interviewees of the Storage Unit

Based on the responses of the storage unit, three main best safety practices are adapted in O&G industry in Bahrain which are Solomon Fuels Study, Operational Excellence and Chevron umbrella. In this regard, Interviewee 10, Interviewee 11 and Interviewee 12 agreed that Solomon Fuels Study is adapted in this industry. For example, Interviewee 11 stated, “We adapt Solomon Fuels Study and we achieve fundamental positive improvements in skill, efficiency and effectiveness of the workplaces." Additionally, one single response (interviewee 9) was collected for Operational Excellence and another single response (interviewee 10) was collected for Chevron umbrella. Interviewee 9 stated, "We adapt several international standards and operational excellence. We adapted Operational Excellence since 2010 to reach the operational effectiveness and better performance level in our industry.It covers also some environmental considerations and cost effectiveness" While Interviewee 10 stated, "W operate under Chevron umberella."

4.3.3.4 The Need for Safety Strategy in O&G Industry in Bahrain

Figure 4.30 visualises the coding structure of these responses while Figure 4.31 shows the cognitive mapping of these responses.

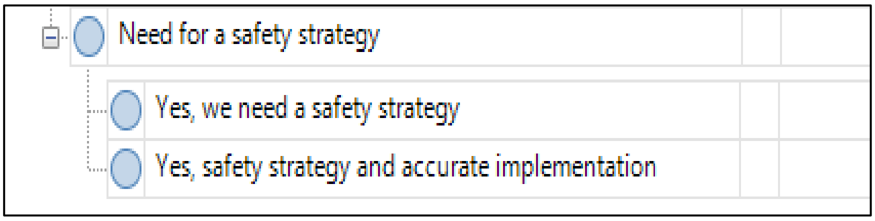

Figure 4.30: Coding Structure for the Need for a Safety Strategy Based on the Interviewees of the Storage Unit

Figure 4.31: Cognitive Mapping for the Need for a Safety Strategy Based on the Interviewees of the Storage Unit

According to the need for safety strategy, all the responses of the managerial level (Interviewee 9, Interviewee 10, Interviewee 11 and Interviewee 12) of the storage unit agreed that O&G industry in Bahrain needs to build a safety strategy. In Interviewee 11's words, "Having a comprehensive updated safety strategy is important to our industry. It should be developed by professionals from different fields. And there should be a strong commitment to it from all and especially top management." With this though Interviewee 11 pointed out that professionals should play a key role in building this strategy and a visible commitment to this strategy from all is required as well. This was affirmed by Interviewee 12 who said, “After the new oil exploration, building a safety strategy should be prepared form now by a multi-professional team and a governmental regulatory team in order to cover and mediate between issues and conflicts. However, there should be a structured study that designs precisely the implementation of this strategy and explains clearly the role of each worker within this strategy.” On top of that, Interviewee 9 endorsed the importance of not just developing this strategy but also the importance of accurate implementing for this strategy.

At this point, the results of analysing the qualitative data of the semi-structured interviews with the managerial level of each case are discussed and presented. These results cover the current OHS framework in O&G industry, human error accidents and its related challenges in O&G industry in Bahrain, adapted best safety practices and the need for safety strategy in O&G industry in Bahrain in each case. The next section presents the case study analysis for the quantitative data of the questionnaire survey.

4.4 Case study Analysis for the Quantitative Data

With the aim of supporting the information obtained from the semi-structured interviews, questionnaire surveys were developed and distributed over the operational level of the refining, distributing and storage units in the downstream of the O&G industry in Bahrain. The sample size was based on the sample size table of Krejcie and Morgan (1970). Accordingly, in total 226 questionnaires (75 copies of the questionnaire survey were distributed over the operational level of each unit and one copy was given to the representative who was responsible for administrating these three units) were distributed over the three units, out of which 163 were answered, completed and received by the researcher. The response rate was 72%. The response rate was considered very satisfactory.

The questionnaires consisted of three sections in which the first section contained 3 questions, the second section contained 8 questions and the third one contained 26 questions. Most of questions were with multiple choice or structured using Likert scale. By appointing a representative from Company A, an introduction that described the purpose of the questionnaire was given to all participants. Through this introduction, all respondents were informed that they are able to ask any question at any stage. They were informed that anonymity and data protection were assured precisely with all stages. Respondents also informed that the participation in this questionnaire is voluntary and withdrawing from the questionnaire is acceptable at any stage without giving any reason. The questionnaire covered the following objectives:

- Critically evaluate the challenges related to human errors specific accidents in O&G industry in Bahrain.
- Refine and validate the recommendations of the industrial safety strategy for the O&G industry in Bahrain.

After receiving the questionnaire surveys data from operational level's respondents, these data was keyed and processed using a suitable specialised computer programme for analysing statistics SPSS (version 24.0). The analysis of these data involved three steps. The first step was entering and coding the collected data. The second step was processing the data in SPSS. The final step was generating the best visualisation of data through the descriptive and inferential statistical analysis in order to draw the final conclusions. The results of this analysis are provided in the next sections.

4.4.1 Case 1: Refining Unit

Within the refining unit, participants of the questionnaire surveys were all male and they were familiar with the environment of this unit. 57 valid and completed responses were received from this unit. Respondents had different occupations of the operational level ranging from engineers and supervisors to drivers. The next section provides an overview of preliminary results of the questionnaire surveys from this unit.

4.4.1.1 Questionnaire Findings

The questionnaire survey has three main sections: participant's background information, workplace information, and opinions on workplace. The results of these sections are presented in the following sub-sections.

4.4.1.1.1 Participants’ Background

The first section provides the profile of the participants such as the age, position and experience in O&G industry. In the first question, respondents were asked to comment on their age. The results showed that (19.30%) were between 20 and 30 years old, (28.07%) were between 30 and 40 years old, (31.58%) were between 40 and 50 years old, (15.79%) were between 50 and 60 years old and (5.26%) were over 60 years old. These results are shown in Figure 4.32. Based on these results, a half of respondents was between 30 and 50 years.

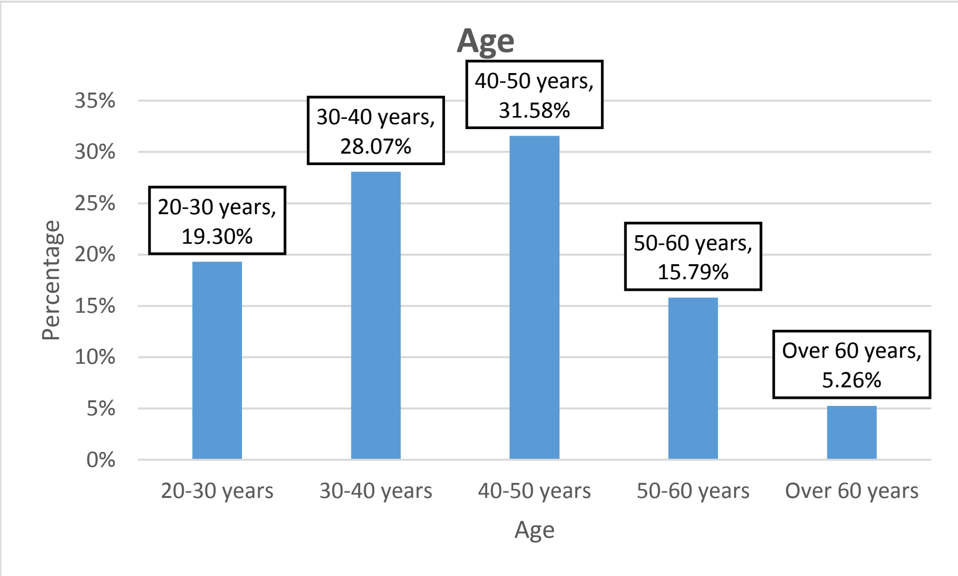

Figure 4.32: Q1_Age of Participants of the Refining Unit

The second question in this section is an optional question which asked the participants to write down their occupation. 42 responses were received. A wide range of occupations of the operational level was identified like engineers, technicians, specialists, operators, labour analysts, supervisors, drivers and safety officers. These results are presented in Figure 4.33.

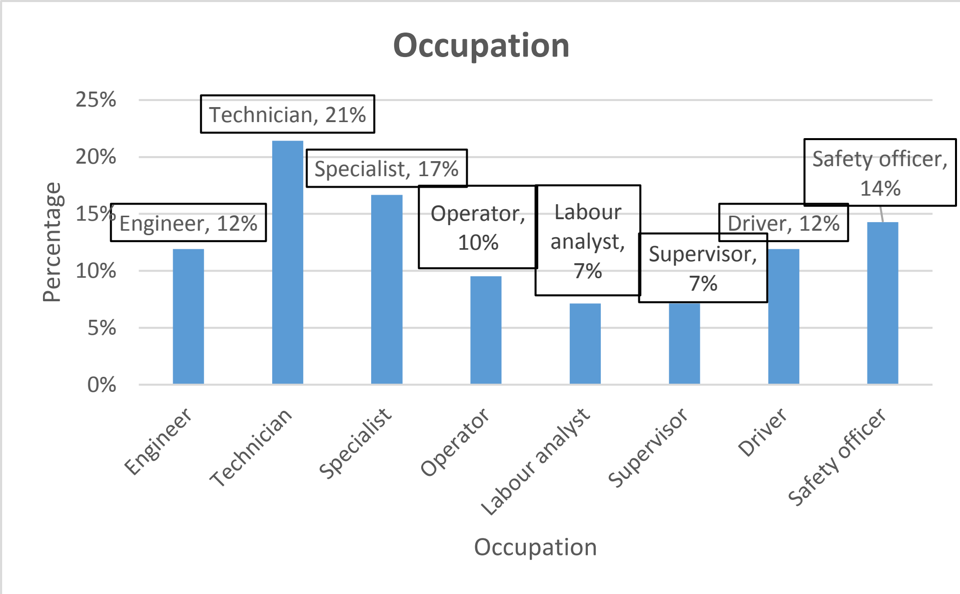

Figure 4.33: Q2_Occupation of Participants of the Refining Unit

In the third and last question in this section, the participants were asked to comment on their experience in O&G industry. Among the 57 respondents, (22.81%) were with 0-5 years of experience, (22.80%) were with 6-10 years of experience, (38.60%) were with 11-15 years of experience and (15.79%) were with more than 15 years of experience. The results of experience are presented in Figure 4.34.

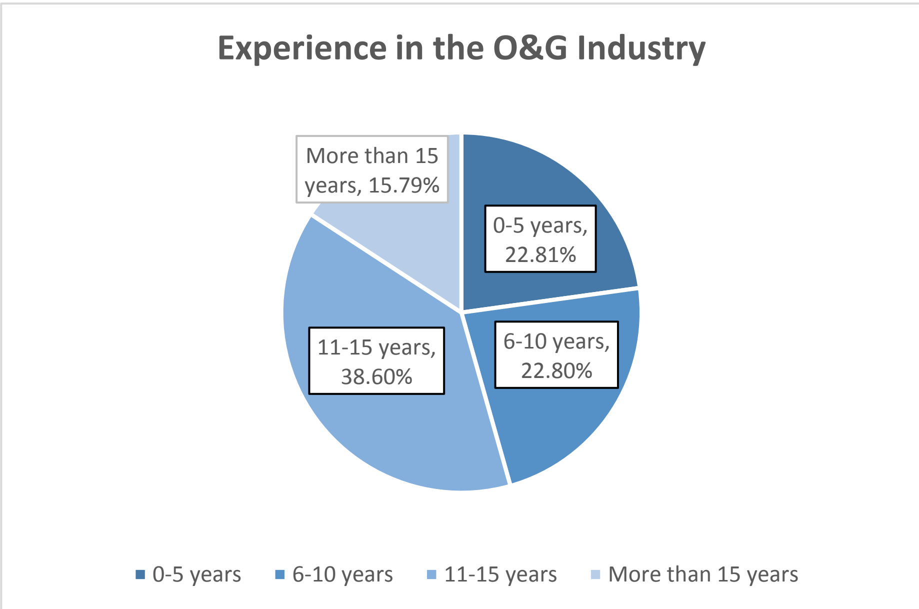

Figure 4.34: Q3_Experience in the Oil and Gas Industry of Participants of the Refining Unit

4.4.1.1.2 Workplace information

The second section provides the main characteristics of the workplace. In this section, respondents were asked 8 questions including an optional question about safety qualification. In the first question, respondents were asked about their work schedule type. Fixed work schedule accounted nearly for a quarter of respondents (24.56%) while shifts work schedule accounted nearly for three quarters of respondents (75.44%). Figure 4.35 summarises that.

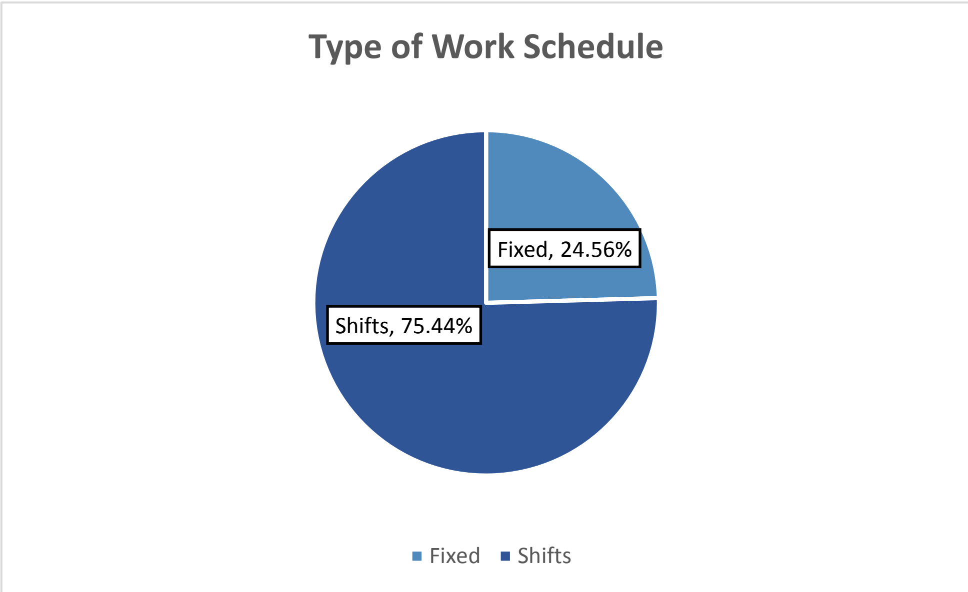

Figure 4.35: Q1_Type of Work Schedule of Participants of the Refining Unit

In the second question, respondents were asked about their average weekly working hours and the results showed that (77.19%) of respondents worked for 40-49 hours per week and (22.81%) of respondents worked for 50-59 hours per week. No one worked for more than 60 hours per week. A summary for that is tabulated in Table 4.2.

Table 4.2: Q2_Weekly Working Hours of Participants of the Refining Unit

Weekly Working Hours	Number of Responses	Percentage
40-49 hours	44	77.19%
50-59 hours	13	22.81%
Total	57	100.00%

In the third question, respondents had an optional question about their safety qualification. Two types of safety qualifications were gathered as firefighting certificate and safety induction course. Firefighting certificate is basic principles and responses for fire accidents while safety induction is a wide range of safety instructions and precautions based on each workplace circumstances. In the fourth question, respondents were asked about the Level of risk in their workplace. Figure 4.36 presents the opinions regarding that. The majority of respondents with (80.70%) agreed that their workplace has a high level of risk. In comparison, (19.30%) of respondents agreed that their workplace has a medium level of risk while no one agreed that their workplace has a low level of risk.

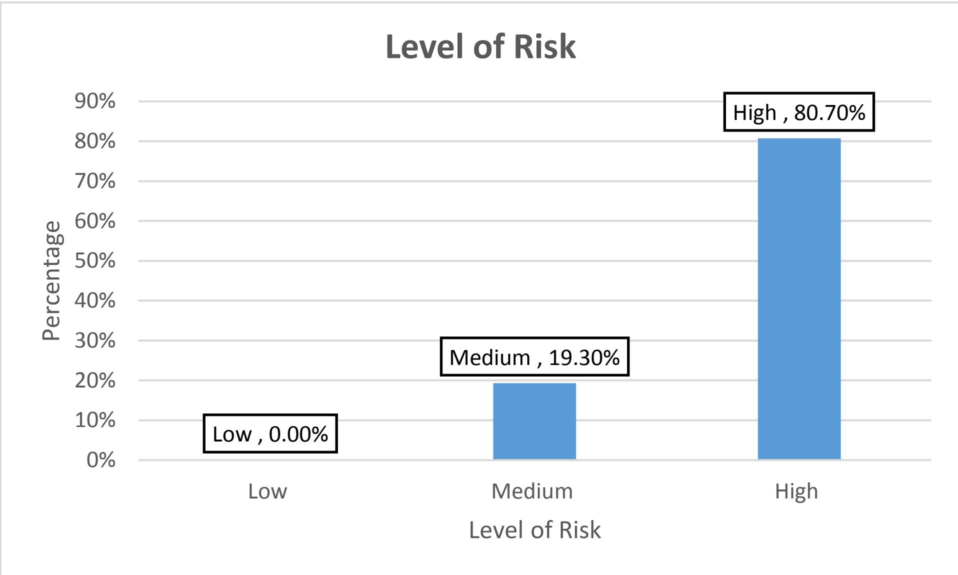

Figure 4.36: Q4_Level of Risk in the Refining Unit

In the fifth question, respondents were asked about the need of PPE in their job. A significant portion of respondents with (78.95%) selected 'Always' for the need of PPE whereas the remained portion of them with (21.05%) selected 'Sometimes' for the need of PPE in their job. These results are shown in Table 4.3.

Table 4.3: Q5_Need of Personal Protective Equipment in Job in the Refining Unit

Need of PPE	Number of responses	Percentage
Sometimes	12	21.05%
Always	45	78.95%
Total	57	100.00%

In the sixth question, respondents were asked about their work location whether it is indoor or outdoor and this information is presented in Figure 4.37. (68.42%) of respondents were with indoor work location while the remaining of 92 (31.58%) were with outdoor work location.

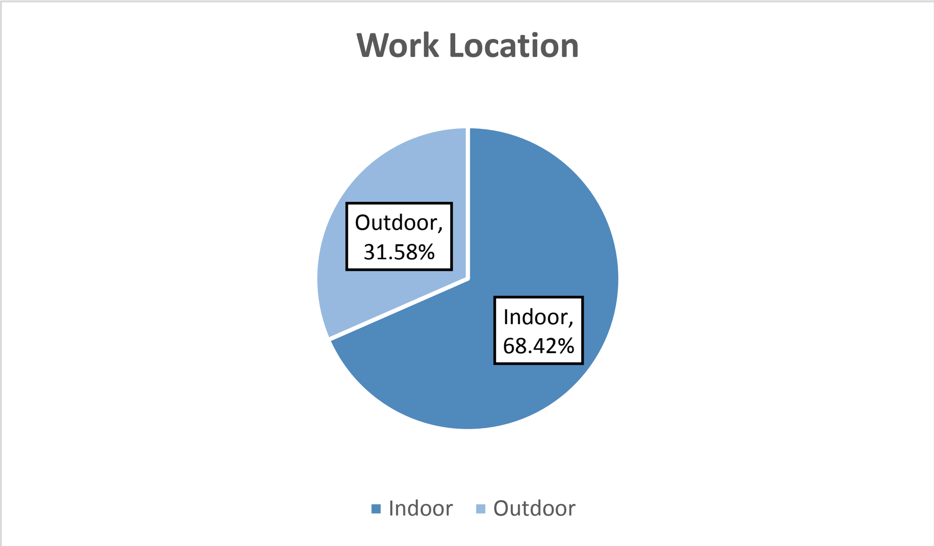

Figure 4.37: Q6_Work Location of Participants of the Refining Unit

In the seventh question, respondents were asked about the noise level in their workplace environment. A significant portion constituted the vast majority of refining unit's participants with (78.95%) agreed that the workplace is with high level of noise. Whilst the remaining percentages were for medium and low with (15.79%) and (5.26%) respectively as shown in Figure 4.38.

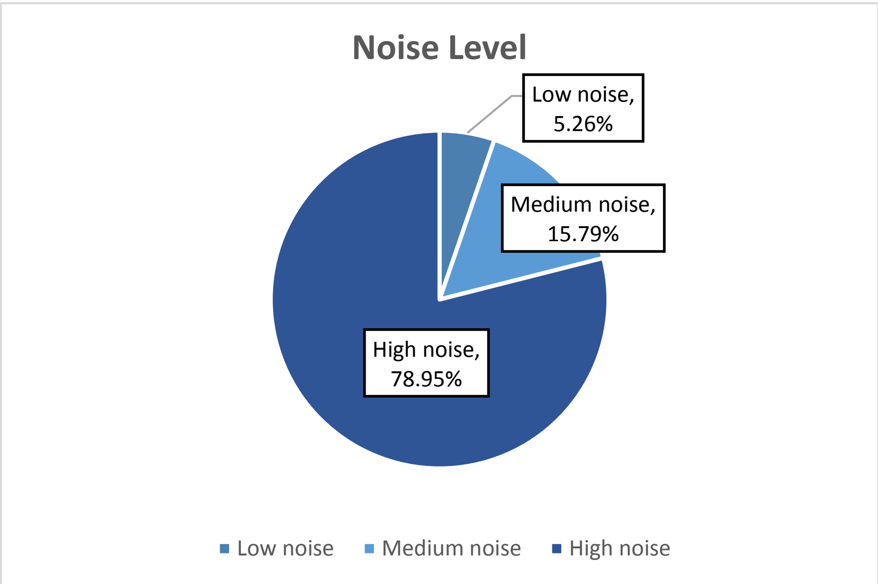

Figure 4.38: Q7_Noise Level in the Refining Unit

Finally, in the eighth question, respondents were asked about the clarity of the communication language between different workers. Responses are represented in Figure 4.39 and it included (57.89%) for bad communication language, (26.32%) for medium communication language and (15.79%) for good communication language.

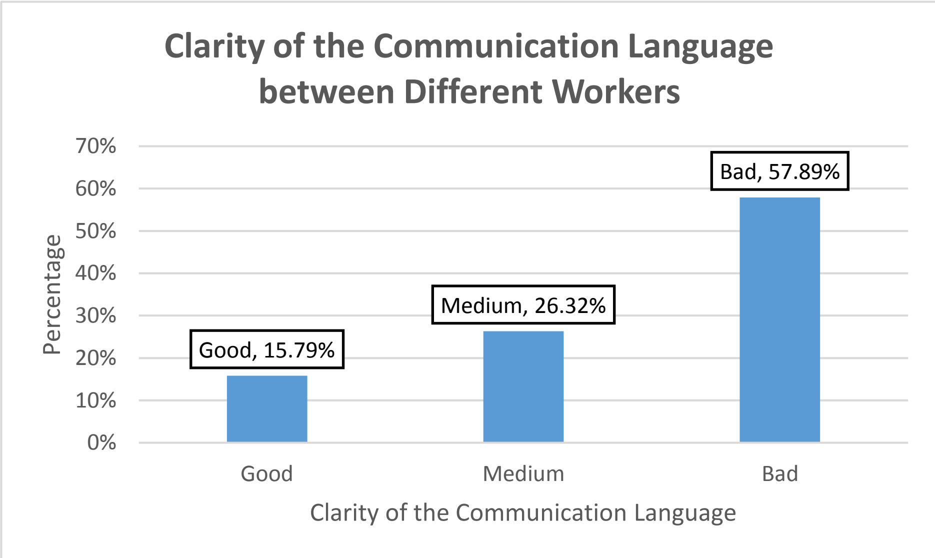

Figure 4.39: Q8_Clarity of the Communication Language between Different Workers in the Refining Unit

4.4.1.1.3 Opinions on Workplace

The third section provides the opinions of the operational level of the refining unit against specific factors in the workplace using five points Likert Scale, 'Strongly disagree' = 1, 'Disagree' = 2, 'Neither agree or disagree' = 3, 'Agree' = 4, and 'Strongly agree' = 5. In this section, respondents were asked to judge and evaluate 26 items *(which are the attributes)* related to seven main challenges *(constructs)* that were discussed in Chapter 1 and Chapter 3. These constructs are Safety regulation, Safety implementation, Top management, Safety training, Safety leadership, Communication and Accidents reporting system. All these judgments were analysed in SPSS (version 24.0). The results of the descriptive and inferential analyses are presented in the next sub-sections.

4.4.1.1.3.1 Results of the Descriptive Analysis

57 responses from the refining unit were analysed using the SPSS (version 24.0) to critically evaluate *Safety_regulation*, *Safety_implementation*, *Top_management, Safety_training,*

Safety_leadership, *Communication* and *Accidents_reporting_system* (constructs) in this unit. The means, medians, modes and standard deviations pertaining to these seven constructs of interest in the refining unit are presented in Table 4.4.

Table 4.4: Descriptive Statistics for the Seven Constructs in the Refining Unit

Item	Mean	Median	Mode	Standard Deviation	Result
Safety_regulation	3.45	3.60	3.80	0.772	Agree (not a challenge)
Safety_implementation	2.35	2.50	3.00	0.754	**Disagree (a challenge)**
Top_management	3.50	4.00	4.00	1.022	Agree (not a challenge)
Safety_training	2.50	2.33	1	1.158	**Disagree (a challenge)**
Safety_leadership	2.55	2.250	4	1.119	**Disagree (a challenge)**
Communication	2.03	2.00	2	0.436	**Disagree (a challenge)**
Accidents_reporting_system	2.36	2.33	3	0.934	**Disagree (a challenge)**

The highest mean was for *Top_management* while the lowest mean was for *Communication*. The weighted mean determines the direction of the opinion for each statement based on the average statement and it is calculated from the results of respondents' answers compared with the theoretical average that is shown in Table 4.5

Table 4.5: 5-Likert Scale and the Theoretical Weighted Mean

Response	The Weighted Mean
Strongly disagree	1.00-1.80
Disagree	1.81-2.60
Neither agree nor disagree	2.61-3.40
Agree	3.41-4.20
Strongly agree	4.21-5.00

Accordingly, by comparing the weighted mean level of agreement on the scores of the first column (Mean) and the theoretical average in Table 4.5, the last column (Result) in Table 4.4 was generated in order to give a conclusion on the level of agreement on the seven constructs. Thus, the scores in the last column (Result) express the opinions of the refining unit's respondents. Results reveals that the respondents of the refining unit agreed that *Safety_implementation*, *Safety_training,* *Safety_leadership*, *Communication* and *Accidents_reporting_system* are only challenges related to human error accidents.

4.4.1.1.3.2 Results of the Inferential Analysis

An examination of the scatterplots (not presented) suggested that there is a linearity between the resulted five challenges. The presence of linearity permitted the use of correlation coefficients. According to the distribution of scores underlying these challenges, the standardized skewness coefficients (dividing the skewness by the standard error of skewness) and the standardized kurtosis coefficients (dividing the kurtosis by the standard error of kurtosis) revealed serious departures from normality for these challenges. Results were outside of the limits of normality +/- 1.96, and were indicative of serious departures from normality (Onwuegbuzie & Daniel, 2002; Cramer & Howitt, 2004; Doane & Seward, 2011). A Shapiro & Wilk's test that assumes that there is no normal distributed if the p-value is under 0.05 (Shapiro & Wilk, 1965; Razali & Wah, 2011) was also computed. The visual inspection of their histograms, normal Q-Q plots and box plots were examined as well. All these tests indicated that the scores of these five challenges in the refining unit were not normally distributed (Cramer & Howitt, 2004; Doane & Seward, 2011).

4.4.1.1.3.2.1 Spearman's Rank Order Correlation Coefficient

A nonparametric procedure, the Spearman's Rank Order Correlation Coefficient (i.e., Spearman's rho) was computed to assess the correlations between the five challenges. These correlations are reported in Table 4.6.

Table 4.6: Spearman's Rank Order Correlation Coefficient in the Refining Unit

			Safety_ implementation	Safety_training	Safety_ leadership	Communication	Accidents_ reporting_ system
Spearman's rho	Safety_implementation	Correlation Coefficient	1	.610**	.698**	.587**	.659**
		Sig. (2-tailed)	.	.000	.000	.000	.000
		N	57	57	57	57	57
	Safety_training	Correlation Coefficient	.610**	1	.915**	.866**	.598**
		Sig. (2-tailed)	.000	.	.000	.000	.000
		N	57	57	57	57	57
	Safety_leadership	Correlation Coefficient	.698**	.915**	1	.892**	.677**
		Sig. (2-tailed)	.000	.000	.	.000	.000
		N	57	57	57	57	57
	Communication	Correlation Coefficient	.587**	.866**	.892**	1	.614**
		Sig. (2-tailed)	.000	.000	.000	.	.000
		N	57	57	57	57	57

	Accidents_reporting_system	Correlation Coefficient	.659**	.598**	.677**	.614**	1
		Sig. (2-tailed)	.000	.000	.000	.000	.
		N	57	57	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

To understand these correlations, the rule of thumb of Hinkle, Wiersma & Jurs (2003) for interpreting the size of a correlation coefficient was adapted as shown in Table 4.7.

Table 4.7: Rule of Thumb for Interpreting the Size of a Correlation Coefficient (Hinkle et al., 2003)

Size of Correlation	Interpretation
0.90 to 1.00 (−0.90 to −1.00)	Very high positive (negative) correlation
0.70 to 0.90 (−0.70 to −0.90)	High positive (negative) correlation
0.50 to 0.70 (−0.50 to −0.70)	Moderate positive (negative) correlation
0.30 to 0.50 (−0.30 to −0.50)	Low positive (negative) correlation
0.00 to 0.30 (0.00 to −0.30)	Negligible correlation

Based on the above two tables (Table 4.6 and Table 4.7), the Spearman's rho revealed statistically significant moderate, high and very high positive correlations. The effect size of this relationship was small (Cohen, 1988). The significant moderate positive correlations were between:

- *Safety_training* and *Safety_implementation* ($r_s[57] = 0.610$, $p < 0.001$);
- *Safety_leadership* and *Safety_implementation* ($r_s[57] = 0.698$, $p < 0.001$);
- *Communication* and *Safety_implementation* ($r_s[57] = 0.587$, $p < 0.001$);
- *Accidents_reporting_system* and *Safety_implementation* ($r_s[57] = 0.659$, $p < 0.001$);
- *Accidents_reporting_system* and *Safety_training* ($r_s[57] = 0.598$, $p < 0.001$);
- *Accidents_reporting_system* and *Safety_leadership* ($r_s[57] = 0.677$, $p < 0.001$);
- *Accidents_reporting_system* and *Communication* ($r_s[57] = 0.614$, $p < 0.001$).

In each of these correlations, squaring the correlation coefficients indicated by how much the variance in the percent of the first challenge was explained by the presence of the second challenge. For example, 34.4% of the variance in the percent of *Communication* was explained by the presence of *Safety_implementation*. As well as, 48.7% of the variance in the percent of *Safety_leadership* was explained by the presence of *Safety_implementation*.

While the significant high positive correlations were between:

- *Communication* and *Safety_training* (*rs*[57] = 0.866, *p* < 0.001);
- *Communication* and *Safety_leadership* (*rs*[57] = 0.892, *p* < 0.001).

By squaring the correlation coefficients, 75% of the variance in the percent of *Communication* was explained by the presence of *Safety_training*, whereas, 80% of the variance in the percent of *Communication* was explained by the presence of *Safety_leadership*.

However, there was significantly a very high positive correlation between *Safety_leadership* and *Safety_training* (*rs*[57] = 0.915, *p* < 0.001) and by squaring the correlation coefficient 84% of the variance in the percent of *Safety_leadership* was explained by the presence of *Safety_training*. Overall, there were significantly ten positive correlations. The percent of variance explained by each variable ranged between 34.4% and 84%. The strongest correlation coefficient was for the Safety_*leadership* and Safety_*training*: *rs*(57) = +0.915, *p* <0.001. The weakest correlation coefficient was for the *Communication* and Safety_*implementation*: *rs*(57) = +0.587, *p* <0.001.

4.4.1.1.3.2.2 Mann-Whitney U Test

As the scores of the five challenges in the refining unit were not normally distributed, a nonparametric test called Mann-Whitney U test was used. The Mann-Whitney U test is a common non-parametric statistical tests (Kasuya, 2001). It was developed by Mann and Whitney (1947) and Wilcoxon (1945) and it can be referred as the Wilcoxon-Mann- Whitney test or the Wilcoxon sum of ranks test. The Mann-Whitney U test is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. It is an Alternative Non-Parametric Test for T-test (Mangiafico, 2016). Within this test null hypothesis (H0) assumes that the two groups are from the same population (Nachar, 2008). This means that the two independent groups are homogeneous and have the same distribution. The Mann-Whitney U test has two cases with different hypotheses. The first case is when the two distributions have the same shape, then the hypotheses will be:

H0: the distributions of the two groups are equal.

H1: the medians of the two groups are not equal.

While the second case is when the two distributions have a different shape, then the hypotheses will be:

H0: the distributions of scores for the two groups are equal.

H1: the mean ranks of the two groups are not equal.

Accordingly, it was conducted in the refining unit to examine whether fixed schedule employees and shift schedule employees have a similar agreement on each of the five challenges. The results of this test are shown in Table 4.8. The null hypothesis was:

H0: "The mean agreement of fixed schedule employees and shift schedule employees are equal in the refining unit."

Table 4.8: Results of Mann-Whitney U for Work Schedule in the Refining Unit

Item	Work Schedule	N	Mean Rank	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)	Result
Safety_implementation (different shape)	**Fixed**	14	8.43	13.000	-5.422	0.001	**Reject H0**
	Shift	43	35.70				
Safety_training (different shape)	**Fixed**	14	9.50	28.000	-5.128	0.001	**Reject H0**
	Shift	43	35.35				
Safety_leadership (different shape)	**Fixed**	14	7.89	5.500	-5.584	0.001	**Reject H0**
	Shift	43	35.87				
Communication (different shape)	**Fixed**	14	8.64	16.000	-5.442	0.001	**Reject H0**
	Shift	43	35.63				
Accidents_reporting_system (different shape)	**Fixed**	14	11.07	50.000	-4.691	0.001	**Reject H0**
	Shift	43	34.84				

Based on the results from the Mann-Whitney U test in the refining unit in Table 4.8 regarding the agreement that safety implementation is a challenge to human error accidents in the refining unit, results showed a significant difference (U = 8, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 35.81 compared to 8.07 for fixed schedule employees suggesting that those of shift schedule consider safety implementation more as a challenge. The effect size was large (0.72). Regarding the agreement that safety training is a challenge to human error accidents in the refining unit, results also revealed a significant difference (U = 28, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 35.35 compared to 9.50 for fixed schedule employees suggesting that those of shift schedule consider safety training more as a challenge. The effect size was large (0.68) (Cohen, 1988).

Then, regarding the agreement that safety leadership is a challenge to human error accidents in the refining unit, results showed a significant difference (U = 5.5, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 35.87 compared to 7.89 for fixed schedule employees suggesting that those of shift schedule consider safety leadership more as a challenge. The effect size was large (0.74) (Cohen, 1988). While regarding the agreement that communication is a challenge to human error accidents in the refining unit, results revealed a significant difference (U = 16, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 35.63 compared to 8.64 for fixed schedule employees suggesting that those of shift schedule consider communication more as a challenge. The effect size was large (0.72) (Cohen, 1988).

Finally and regarding the agreement that accidents reporting system is a challenge to human error accidents in the refining unit, results showed a significant difference (U = 50, p = 0.001) between fixed schedule employees and shift schedule employees on the agreement that accidents reporting system is a challenge to human error accidents in the refining unit. The mean rank for shift schedule employees was 34.84 compared to 11.07 for fixed schedule employees suggesting that those of shift schedule consider accidents reporting system more as a challenge. The effect size was large (0.62) (Cohen, 1988).

Apart from all that, a Mann-Whitney U test was conducted also in this unit to examine whether indoor employees and outdoor employees have a similar agreement on each of the five challenges in the refining unit. The results of this test are presented in Table 4.9. The null hypothesis was:

H0: "The mean agreement of indoor employees and outdoor employees are equal in the refining unit."

Table 4.9: Results of Mann-Whitney U for Work Location in the Refining Unit

Item	Work Location	N	Mean Rank	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)	Result
Safety_implementation (different shape)	**Indoor**	39	23.32	129.500	-3.830	0.001	**Reject H0**
	Outdoor	18	41.31				
Safety_training (different shape)	**Indoor**	39	20.46	18.000	-5.792	0.001	**Reject H0**
	Outdoor	18	47.50				
Safety_leadership (different shape)	**Indoor**	39	20.05	2.000	-6.107	0.001	**Reject H0**
	Outdoor	18	48.39				
Communication (different shape)	**Indoor**	39	21.10	43.000	-5.446	0.001	**Reject H0**
	Outdoor	18	46.11				
Accidents_reporting_system (different shape)	**Indoor**	39	23.19	124.500	-3.920	0.001	**Reject H0**
	Outdoor	18	41.58				

Regarding the agreement that safety implementation is a challenge to human error accidents in the refining unit, results also revealed a significant difference (U = 129.5, p = 0.001) between indoor employees and outdoor employees. The mean rank for outdoor employees was 41.31 compared to 23.32 for indoor employees suggesting that those of outdoor work location consider safety implementation more as a challenge. The effect size was medium (0.51) (Cohen, 1988).

Further, regarding the agreement that safety training is a challenge to human error accidents in the refining unit, results also revealed a significant difference (U = 18, p = 0.001) between indoor employees and outdoor employees. The mean rank for outdoor employees was 47.50 compared to 20.46 for indoor employees suggesting that those of outdoor work location consider safety training more as a challenge. The effect size was large (0.77) (Cohen, 1988). Then, regarding the agreement that safety leadership is a challenge to human error accidents in the refining unit, results showed a significant difference (U = 2, p = 0.001) between indoor employees and outdoor employees. The mean rank for outdoor employees was 48.39 compared to 20.05 for indoor employees suggesting that those of outdoor work location consider safety leadership more as a challenge. The effect size was large (0.81) (Cohen, 1988).

While regarding the agreement that communication is a challenge to human error accidents in the refining unit, results revealed a significant difference (U = 43, p = 0.001) between indoor employees and outdoor employees. The mean rank for outdoor employees was 46.11 compared to 21.10 for indoor employees suggesting that those of outdoor work location consider communication more as a challenge. The effect size was large (0.72) (Cohen, 1988). Finally and regarding the agreement that accidents reporting system is a challenge to human error accidents in the refining unit, results showed a significant difference (U = 124.5, p = 0.001) between indoor employees and outdoor employees on the agreement that accidents reporting system is a challenge to human error accidents in the refining unit. The mean rank for outdoor employees was 41.58 compared to 23.19 for indoor employees suggesting that those of outdoor work location consider accidents reporting system more as a challenge. The effect size was medium (0.52) (Cohen, 1988).

Overall, a Mann-Whitney U test indicated that the agreement on the five challenges related to human error accidents (*Safety_implementation*, *Safety_training, Safety_leadership*, *Communication* and *Accidents_reporting_system)* in the refining unit was significantly greater for shift schedule employees than for fixed schedule employees. Similarly, this test indicated that the agreement on these five challenges in the refining unit was significantly greater for outdoor employees than for indoor employees.

The next section presents the results of analysing the quantitative data of the distributing unit.

4.4.2 Case 2: Distributing Unit

Within the distributing unit, participants of the questionnaire surveys were all male and they were familiar with the environment of this unit. 52 valid and completed responses were received from this unit. Respondents had different occupations of the operational level ranging from engineers and supervisors to drivers. The next section provides an overview of preliminary results of the questionnaire surveys in this unit.

4.4.2.1 Questionnaire Findings

The questionnaire survey has three main sections: participant's background, workplace information, and opinions on workplace. The results of these sections are presented in the following sub-sections.

4.4.2.1.1 Participants' Background information

This section presents the profile of the participants by specifying age, position and experience of those respondents. In the first question, respondents were asked to comment on their age. The results showed that (16.67%) were between 20 and 30 years old, (18.52%) were between 30 and 40 years old, (40.74%) were between 40 and 50 years old, (16.67%) were between 50 and 60 years old and (7.41%) were over 60 years old. These results are shown in Figure 4.40. Based on these results, the ages between 40 and 50 years reserved the highest responses.

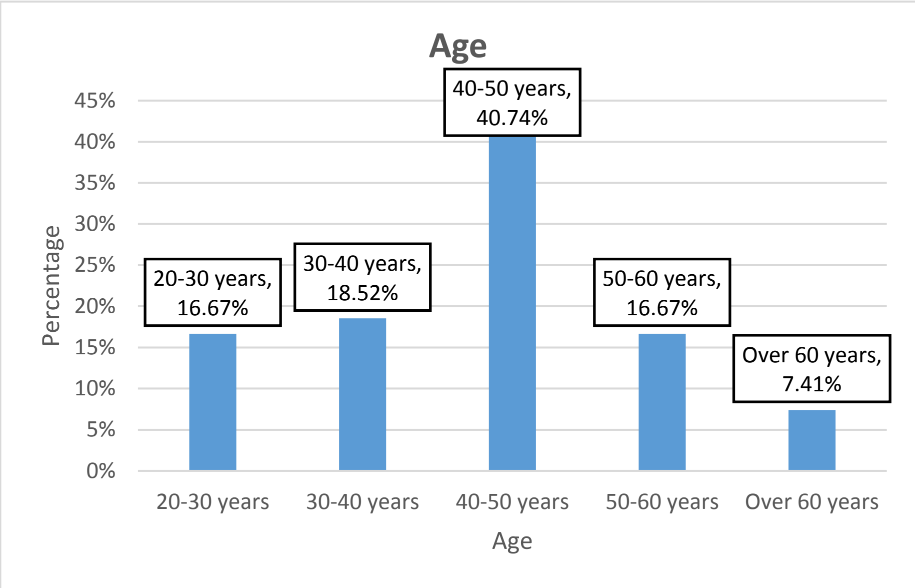

Figure 4.40: Q1_Age of Participants of the Distributing Unit

The second question is an optional question which asked the participants to write down their occupation. 33 responses were received like technicians, specialists, labour analysts, engineers, operators, supervisors, drivers and safety officers. These results are presented in Figure 4.41.

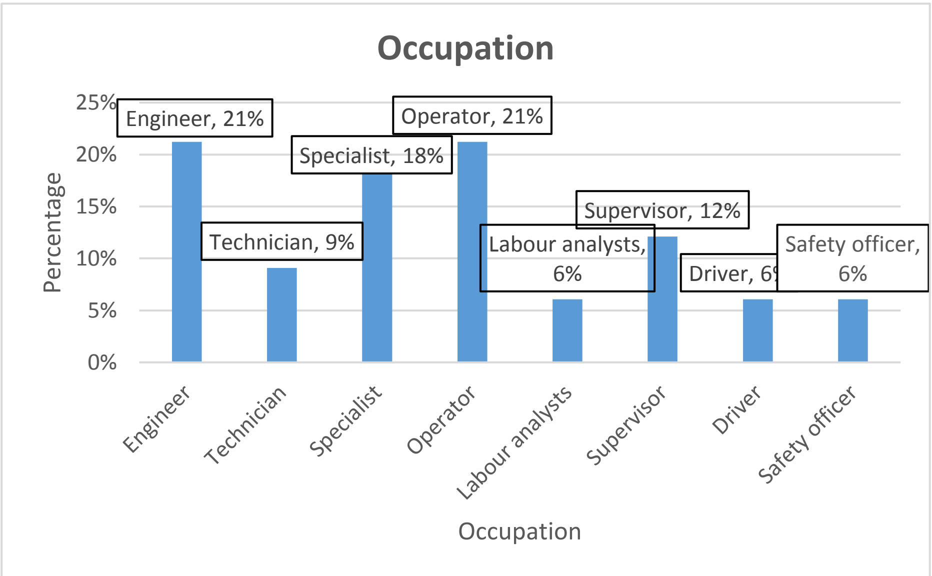

Figure 4.41: Q2_Occupation of Participants of the Distributing Unit

In the third and last question in this section, the participants were asked to comment on their experience in O&G industry. Among the 52 respondents, (26.92%) were with 0-5 years of experience, (17.32%) were with 6-10 years of experience, (40.38%) were with 11-15 years of experience and (15.38%) were with more than 15 years of experience. The results of experience are presented in Figure 4.42.

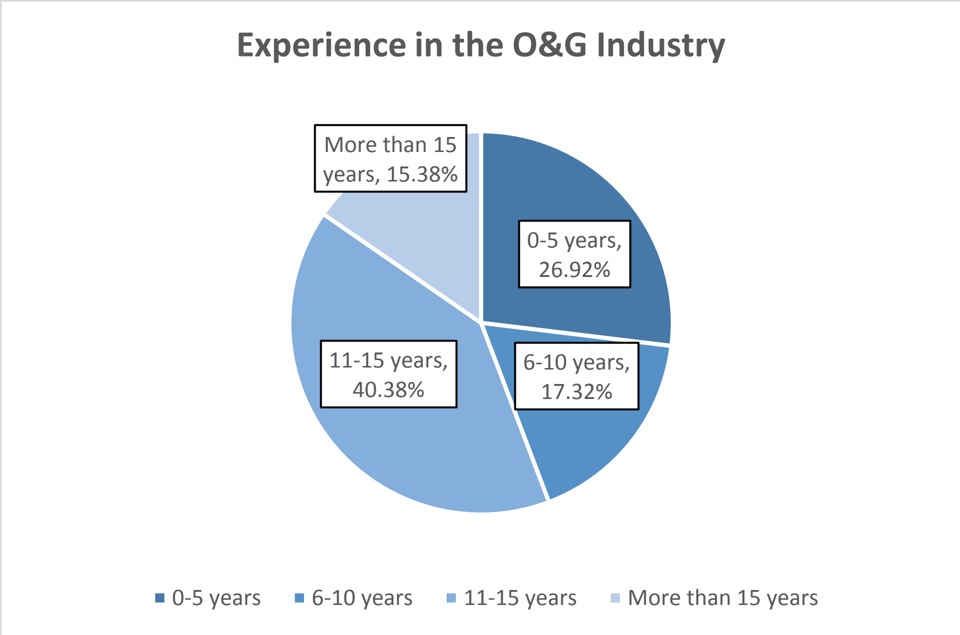

Figure 4.42: Q3_Experience in the O&G Industry of Participants of the Distributing Unit

4.4.2.1.2 Workplace information

The second section provides the main characteristics of the workplace. In this section, respondents were asked 8 questions including an optional question about safety qualifications. In the first question, respondents were asked about the type of thier work schedule. Fixed work schedule accounted for a small portion of respondent with (11.59%) while shifts work schedule accounted more than (85%) of respondents. Figure 4.43 summarises that.

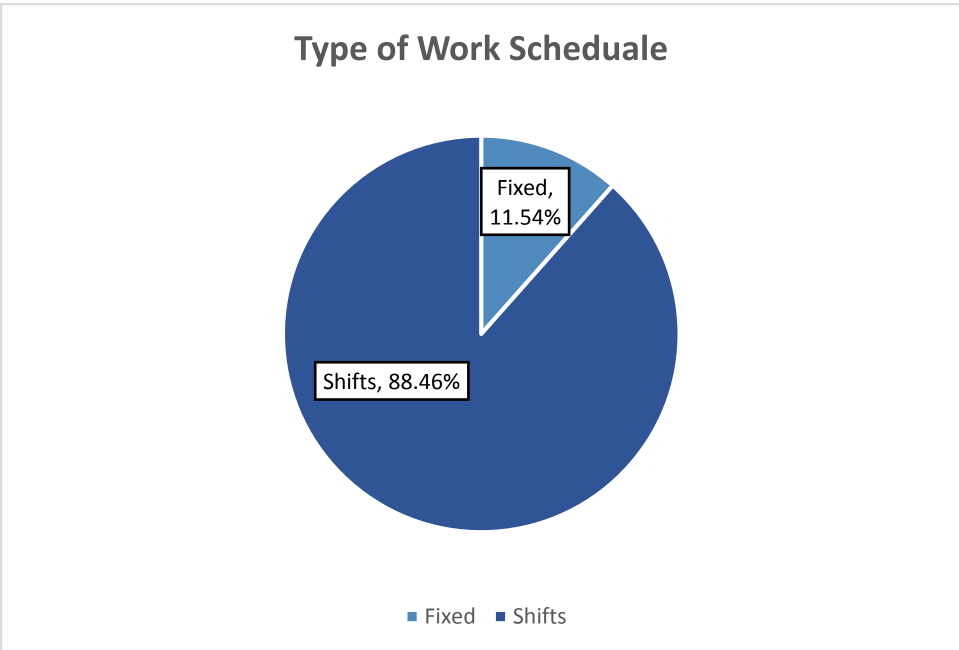

Figure 4.43: Q1_ Type of Work Schedule of Participants of the Distributing Unit

In the second question, respondents were asked about their weekly working hours and the results showed that (76.92%) of respondents worked for 40-49 hours per week and (23.08%) of respondents worked for 50-59 hours per week. A summary for that is tabulated in Table 4.10.

Table 4.10: Q2_Weekly Working Hours of Participants of the Distributing Unit

Weekly Working Hours	Number of Responses	Percentage
40-49 hours	40	76.92%
50-59 hours	12	23.08%
Total	52	100.00%

In the third question, respondents had an optional question about their safety qualification. One type of safety qualification was gathered which was firefighting certificate. In the fourth question, respondents were asked about the level of risk in their workplace. Figure 4.44 presents that the majority of respondents with (86.54%) agreed that their workplace has a high level of risk while the remaining percentage of (13.46%) of respondents indicated that their workplace has a medium level of risk.

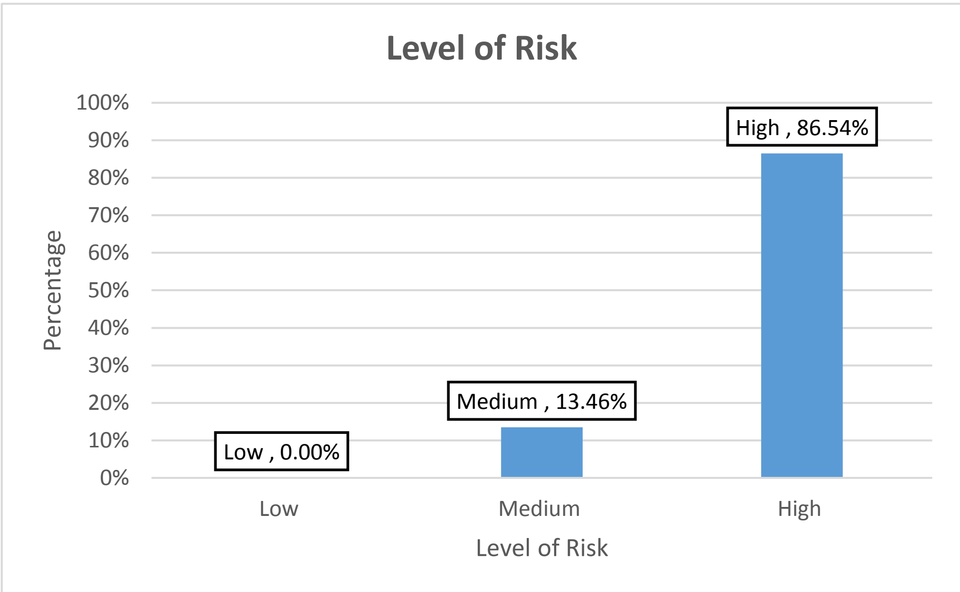

Figure 4.44: Q4_Level of Risk in the Distributing Unit

In the fifth question, respondents were asked about the need of PPE while carrying out their job. A significant portion of respondents with (82.69%) selected ‘Always’ for the need of PPE whereas the remained portion of them with (17.31%) selected 'Sometimes' for the need of PPE in their job. These results are shown in Table 4.11.

Table 4.11: Q5_Need of Personal Protective Equipment in Job in the Distributing Unit

Need of PPE	Number of responses	Percentage
Sometimes	9	17.31%
Always	43	82.69%
Total	52	100.00%

In the sixth question, respondents were asked about their work location whether it is indoor or outdoor and this information is presented in Figure 4.45. Only one quarter of respondents pointed that they worked with outdoor work location while the remaining three quarters of respondents pointed that they worked with indoor work location.

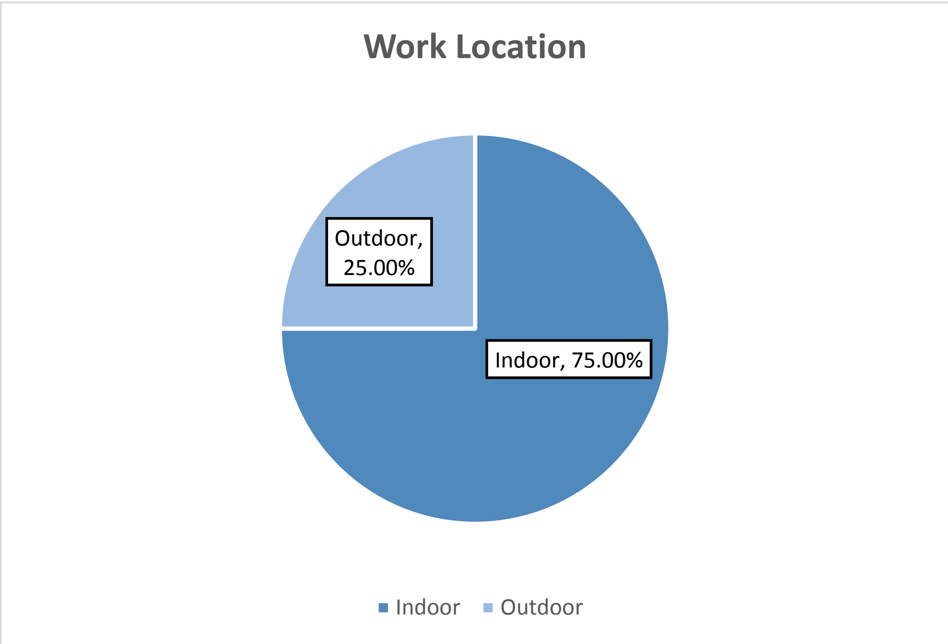

Figure 4.45: Q6_Work Location of Participants of the Distributing Unit

In the seventh question, respondents were asked about the noise level in their workplace. A significant portion constituted the vast majority of distributing unit's participants with (82.69%) agreed that the workplace is with high level of noise. Whilst the remaining percentages were for medium and low with (9.62%) and (7.69%) respectively as shown in Figure 4.46.

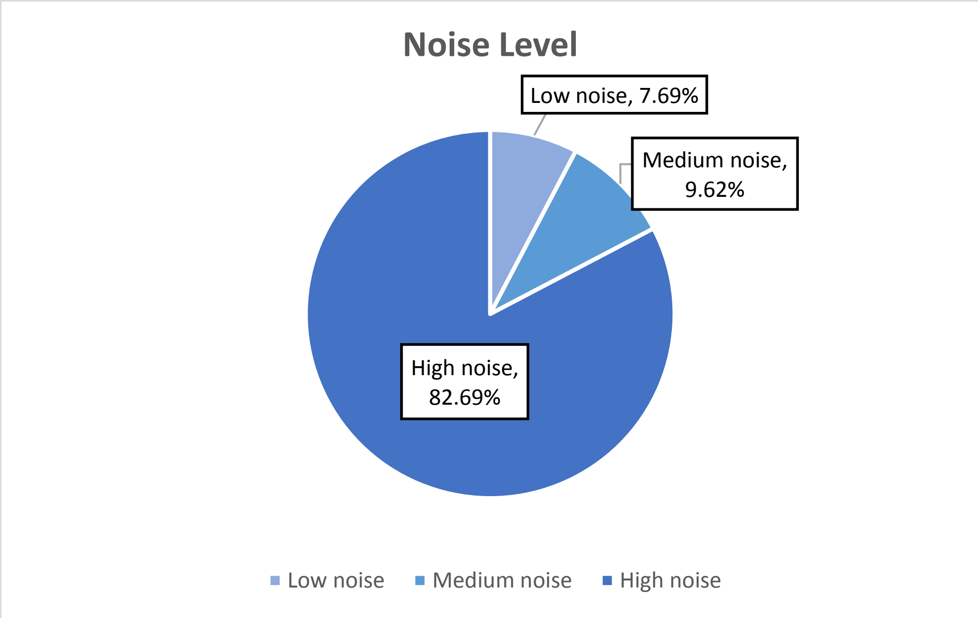

Figure 4.46: Q7_Noise Level in the Distributing Unit

Lastly, in the eighth question, respondents were asked about the clarity of the communication language between different workers. Responses are represented in Figure 4.47 and it included (61.54%) for bad communication language, (30.77%) for medium communication language and (7.69%) for good communication language.

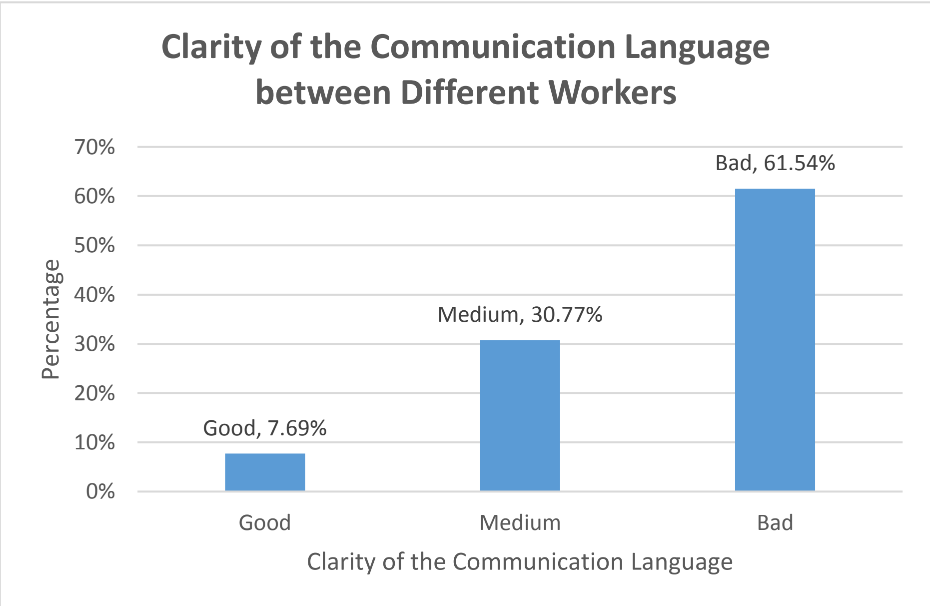

Figure 4.47: Q8_Clarity of the Communication Language between Different Workers in the Distributing Unit

4.4.2.1.3 Opinions on Workplace

The third section provides the opinions of the operational level of the distributing unit against *Safety_regulation, Safety_implementation, Top_management, Safety_training, Safety_leadership, Communication and Accidents_reporting_system* constructs through five points Likert Scale. These opinions and judgments were analysed in SPSS through Spearman's Rank Order Correlation Coefficient and Mann-Whitney U Test. The results of the descriptive and inferential analyses are presented in the next sub-sections.

4.4.2.1.3.1 Results of the Descriptive Analysis

52 responses from the distributing unit were analysed using the SPSS (version 24.0) to critically evaluate *Safety_regulation*, *Safety_implementation*, *Top_management, Safety_training, Safety_leadership*, *Communication* and *Accidents_reporting_system* (constructs) in this unit. The means, medians, modes and standard deviations pertaining to these seven constructs of interest in the distributing unit are presented in Table 4.12.

Table 4.12: Descriptive Statistics for the Seven Constructs in the Distributing Unit

Item	Mean	Median	Mode	Standard Deviation	Result
Safety_regulation	2.53	2.40	2.20	0.925	**Disagree (a challenge)**
Safety_implementation	2.50	2.50	1.25	0.815	**Disagree (a challenge)**
Top_management	2.85	2.67	2	0.993	**Neither**
Safety_training	2.37	2.33	1.67	0.942	**Disagree (a challenge)**
Safety_leadership	3.71	4.00	4.5	0.746	Agree (not a challenge)
Communication	2.51	2.50	2.25	0.708	**Disagree (a challenge)**

Accidents_reporting_system	2.45	2.33	2	0.935	**Disagree (a challenge)**

The highest mean was for *Safety_leadership* while the lowest mean was for *Safety_training*. By comparing the weighted mean level of agreement on the scores of the first column (Mean) and the theoretical average in Table 4.5, the last column (Result) in Table 4.12 was generated in order to give a conclusion on the level of agreement on the seven constructs. Thus, the scores in the last column (Result) express the opinions of the distributing unit's respondents. Results reveals that the respondents of the distributing unit agreed that *Safety_regulation, Safety_implementation*, *Safety_training*, *Communication* and *Accidents_reporting_system* are only challenges related to human error accidents.

4.4.2.1.3.2 Results of the Inferential Analysis

An examination of the scatterplots (not presented) suggested that there is a linearity between the resulted five challenges. The presence of linearity permitted the use of correlation coefficients. According to the distribution of scores underlying these challenges, the standardized skewness coefficients and the standardized kurtosis coefficients revealed serious departures from normality for these challenges. Results were outside of the limits of normality and were indicative of serious departures from normality (Onwuegbuzie & Daniel, 2002; Cramer & Howitt, 2004; Doane & Seward, 2011). Results from Shapiro & Wilk's test (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots concluded that the scores of these five challenges in the distributing unit were not normally distributed (Cramer & Howitt, 2004; Doane & Seward, 2011).

4.4.2.1.3.2.1 Spearman's Rank Order Correlation Coefficient

A nonparametric procedure, the Spearman's Rank Order Correlation Coefficient was computed to assess the correlations between the five challenges. These correlations are reported in Table 4.13.

Table 4.13: Spearman's Rank Order Correlation Coefficient in the Distributing Unit

			Safety_ regulation	Safety_ implementation	Safety_training	Communication	Accidents_ reporting_ system
Spearman's rho	Safety_regulation	Correlation Coefficient	1	.530**	.694**	.536**	.785**
		Sig. (2-tailed)	.	.000	.000	.000	.000
		N	52	52	52	52	52
	Safety_implementation	Correlation Coefficient	.530**	1	.710**	.492**	.478**
		Sig. (2-tailed)	.000	.	.000	.000	.000
		N	52	52	52	52	52
	Safety_training	Correlation Coefficient	.694**	.710**	1	.607**	.599**
		Sig. (2-tailed)	.000	.000	.	.000	.000
		N	52	52	52	52	52
	Communication	Correlation Coefficient	.536**	.492**	.607**	1	.441**
		Sig. (2-tailed)	.000	.000	.000	.	.001
		N	52	52	52	52	52

	Accidents_reporting_system	Correlation Coefficient	.785**	.478**	.599**	.441**	1
		Sig. (2-tailed)	.000	.000	.000	.001	.
		N	52	52	52	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

Using the rule of thumb of Hinkle et al. (2003) for interpreting the size of a correlation coefficient, the Spearman's rho revealed statistically significant low, moderate and high positive correlations. The effect size of this relationship was small (Cohen, 1988). The significant low positive correlations were between:

- *Communication* and *Safety_implementation* ($rs[52] = 0.492$, $p < 0.001$);
- *Accidents_reporting_system* and *Safety_implementation* ($rs[52] = 0.478$, $p < 0.001$);
- *Accidents_reporting_system* and *Communication* ($rs[52] = 0.441$, $p < 0.001$).

In each of these correlations, squaring the correlation coefficients indicated by how much the variance in the percent of the first challenge was explained by the presence of the second challenge. For example, 19.4% of the variance in the percent of *Accidents_reporting_system* was explained by the presence of *Communication*. As well as, 24.2% of the variance in the percent of *Communication* was explained by the presence of *Safety_implementation*.

While the significant moderate positive correlations were between:

- *Safety_implementation and Safety_regulation* ($rs[52] = 0.530$, $p < 0.001$);
- *Safety_training* and *Safety_regulation* ($rs[52] = 0.694$, $p < 0.001$);
- *Communication* and *Safety_regulation* ($rs[52] = 0.536$, $p < 0.001$);
- *Communication* and *Safety_training* ($rs[52] = 0.607$, $p < 0.001$);
- *Accidents_reporting_system* and *Safety_training* ($rs[52] = 0.599$, $p < 0.001$);

By squaring the correlation coefficients, 28% of the variance in the percent of *Safety_implementation* was explained by the presence of *Safety_regulation*, whereas, 48% of the variance in the percent of *Safety_training* was explained by the presence of *Safety_regulation*.

However, there were significant high positive correlations between

- *Safety_training* and *Safety_implementation* ($rs[52] = 0.710$, $p < 0.001$);
- *Accidents_reporting_system* and *Safety_regulation* ($rs[52] = 0.785$, $p < 0.001$);

By squaring the correlation coefficient, 50% of the variance in the percent of *Safety_training* was explained by the presence of *Safety_implementation*, whereas, 62% of the variance in the percent of *Accidents_reporting_system* was explained by the presence of *Safety_regulation*. Overall, there were significantly ten positive correlations. The percent of variance explained by each variable ranged between 19.4% and 62%. The strongest correlation coefficient was for the *Accidents_reporting_system* and *Safety_regulation*: $rs(52) = +0.785$, $p < 0.001$. The weakest correlation coefficient was for the *Accidents_reporting_system* and *Communication*: $rs(52) = +0.441$, $p < 0.001$.

4.4.2.1.3.2.2 Mann-Whitney U Test

As the scores of the five challenges in the distributing unit were not normally distributed, a nonparametric test called Mann-Whitney U test was conducted in the distributing unit to examine whether fixed schedule employees and shift schedule employees have a similar agreement on each of the five challenges. The results of this test are shown in Table 4.14. The null hypothesis was:

H0: "The mean agreement of fixed schedule employees and shift schedule employees are equal in the distributing unit."

Table 4.14: Results of Mann-Whitney U for Work Schedule in the Distributing Unit

Item	Work Schedule	N	Mean Rank	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)	Result
Safety_regulation (different shape)	**Fixed**	6	3.50	0.000	-3.998	0.001	**Reject H0**
	Shift	46	29.50				
Safety_implementation (different shape)	**Fixed**	6	5.92	14.500	-3.570	0.001	**Reject H0**
	Shift	46	29.18				
Safety_training (different shape)	**Fixed**	6	3.92	2.500	-3.907	0.001	**Reject H0**
	Shift	46	29.45				
Communication (same shape)	**Fixed**	6	20.25	100.500	-1.081	0.280	**Accept H0**
	Shift	46	27.32				
Accidents_reporting_system (different shape)	**Fixed**	6	3.50	0.000	-3.998	0.001	**Reject H0**
	Shift	46	29.50				

Based on the results from the Mann-Whitney U test in the distributing unit in Table 4.14 regarding the agreement that safety regulation is a challenge to human error accidents in the distributing unit, results showed a significant difference (U = 0.0, p = 0.001) between fixed schedule employees and shift schedule employees. In this case, a low value of U= 0.0 was produced due to a large difference between the two samples and it means that there was the maximum possible difference between fixed work schedule sample and shift work schedule sample. Thus, the mean rank for shift schedule employees was 29.50 compared to 3.50 for fixed schedule employees suggesting that those of shift schedule consider safety implementation more as a challenge. The effect size was medium (0.55) (Cohen, 1988).

Then, regarding the agreement that safety implementation is a challenge to human error accidents in the distributing unit, results showed a significant difference (U = 14.5, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 29.18 compared to 5.92 for fixed schedule employees suggesting that those of shift schedule consider safety implementation more as a challenge. The effect size was medium (0.50) (Cohen, 1988). While regarding the agreement that safety training is a challenge to human error accidents in the distributing unit, results also revealed a significant difference (U = 2.5, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 29.45 compared to 3.92 for fixed schedule employees suggesting that those of shift schedule consider safety training more as a challenge. The effect size was medium (0.54) (Cohen, 1988).

As well as, regarding the agreement that communication is a challenge to human error accidents in the distributing unit, results revealed that the distributions of fixed schedule employees and shift schedule employees were equal (U = 100.5, p = 0.280). This means that there was no difference between the agreements on communication challenge of both work schedule groups. The effect size was small (0.15) (Cohen, 1988). Finally and regarding the agreement that accidents reporting system is a challenge to human error accidents in the distributing unit, results showed a significant difference (U = 0.0, p = 0.001) between fixed schedule employees and shift schedule employees on the agreement that accidents reporting system is a challenge to human error accidents in the distributing unit. In this case, a low value of U= 0.0 was produced due to a large difference between the two samples and it means that there was the maximum possible difference between fixed work schedule sample and shift work schedule sample. Accordingly, the mean rank for shift schedule employees was 29.50 compared to 3.50 for fixed schedule employees suggesting that those of shift schedule consider accidents reporting system more as a challenge. The effect size was medium (0.55) (Cohen, 1988).

Apart from all that, a Mann-Whitney U test was conducted also in this unit to examine whether indoor employees and outdoor employees have a similar agreement on each of the five challenges in the distributing unit. The results of this test are presented in Table 4.15. The null hypothesis was:
H0: "The mean agreement of indoor employees and outdoor employees are equal in the distributing unit."

Table 4.15: Results of Mann-Whitney U for Work Location in the Distributing Unit

Item	Work Location	N	Mean Rank	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)	Result
Safety_regulation (different shape)	**Indoor**	39	21.63	63.500	-4.061	0.001	**Reject H0**
	Outdoor	13	41.12				
Safety_ implementation (different shape)	**Indoor**	39	23.31	129.000	-2.655	0.008	**Reject H0**
	Outdoor	13	36.08				
Safety_training (different shape)	**Indoor**	39	22.53	98.500	-3.298	0.001	**Reject H0**
	Outdoor	13	38.42				
Communication (different shape)	**Indoor**	39	21.90	74.000	-3.819	0.001	**Reject H0**
	Outdoor	13	40.31				
Accidents_reporting_system (different shape)	**Indoor**	39	20.91	35.500	-4.660	0.001	**Reject H0**
	Outdoor	13	43.27				

Based on the results from the Mann-Whitney U test in the distributing unit in Table 4.15 regarding the agreement that safety regulation is a challenge to human error accidents in the distributing unit, results showed a significant difference ($U = 63.5$, $p = 0.001$) between indoor employees and outdoor employees. The mean rank for outdoor employees was 41.12 compared to 21.63 for indoor employees suggesting that those of outdoor work location consider safety implementation more as a challenge. The effect size was medium (0.56) (Cohen, 1988). Then, regarding the agreement that safety implementation is a challenge to human error accidents in the distributing unit, results also revealed a significant difference ($U = 129.0$, $p = 0.008$) between indoor employees and outdoor employees. The mean rank for outdoor employees was 36.08 compared to 23.31 for indoor employees suggesting that those of outdoor work location consider safety implementation more as a challenge. The effect size was small (0.37) (Cohen, 1988).

While, regarding the agreement that safety training is a challenge to human error accidents in the distributing unit, results also revealed a significant difference ($U = 98.5$, $p = 0.001$) between indoor employees and outdoor employees. The mean rank for outdoor employees was 38.42 compared to 22.53 for indoor employees suggesting that those of outdoor work location consider safety training more as a challenge. The effect size was small (0.46) (Cohen, 1988). As well as, regarding the agreement that communication is a challenge to human error accidents in the distributing unit, results revealed a significant difference ($U = 74.0$, $p = 0.001$) between indoor employees and outdoor employees. The mean rank for outdoor employees was 40.31 compared to 21.90 for indoor employees suggesting that those of outdoor work location consider communication more as a challenge. The effect size was medium (0.53) (Cohen, 1988). Finally and regarding the agreement that accidents reporting system is a challenge to human error accidents in the distributing unit, results showed a significant difference ($U = 35.5$, $p = 0.001$) between indoor employees and outdoor employees on the agreement that accidents reporting system is a challenge to human error accidents in the distributing unit. The mean rank for outdoor employees was 43.27 compared to 20.91 for indoor employees suggesting that those of outdoor work location consider accidents reporting system more as a challenge. The effect size was medium (0.65) (Cohen, 1988).

Overall, a Mann-Whitney U test indicated that the agreement on four challenges related to human error accidents (*Safety_regulation, Safety_implementation*, *Safety_training* and *Accidents_reporting_system)* in the distributing unit was significantly greater for shift schedule employees than for fixed schedule employees. One exception was presented which was no significant difference between shift schedule employees and fixed schedule employees on the agreement that *Communication* is a challenge to human error accidents. Additionally, this test indicated that the agreement on these five challenges (*Safety_regulation, Safety_implementation*, *Safety_training*, *Communication* and *Accidents_reporting_system)* in the distributing unit was significantly greater for outdoor employees than for indoor employees.

The next section presents the results of analysing the quantitative data of the storage unit.

4.4.3 Case 3: Storage Unit

Within the storage unit, participants of the questionnaire surveys were all male and they were familiar with the environment of this unit. 54 valid and completed responses were received from this unit.respondents had different occupations of the operational level ranging from engineers and supervisors to drivers. The next section provides an overview of preliminary results of the questionnaire surveys in this unit.

4.4.3.1 Questionnaire Findings

The questionnaire survey has three main sections: participant's background, workplace information, and opinions on workplace. The results of these sections are presented in the following sub-sections.

4.4.3.1.1 Participants' Background information

The profile data of the participants are presented in this section like age, position and experience of those respondents. In the first question, respondents were asked to comment on their age. The results showed that (11.11%) were between 20 and 30 years old, (22.22%) were between 30 and 40 years old, (38.89%) were between 40 and 50 years old, (20.37%) were between 50 and 60 years old and (7.41%) were over 60 years old. These results are shown in Figure 4.48. Based on these results, the ages between 40 and 50 years were more than one third of respondents.

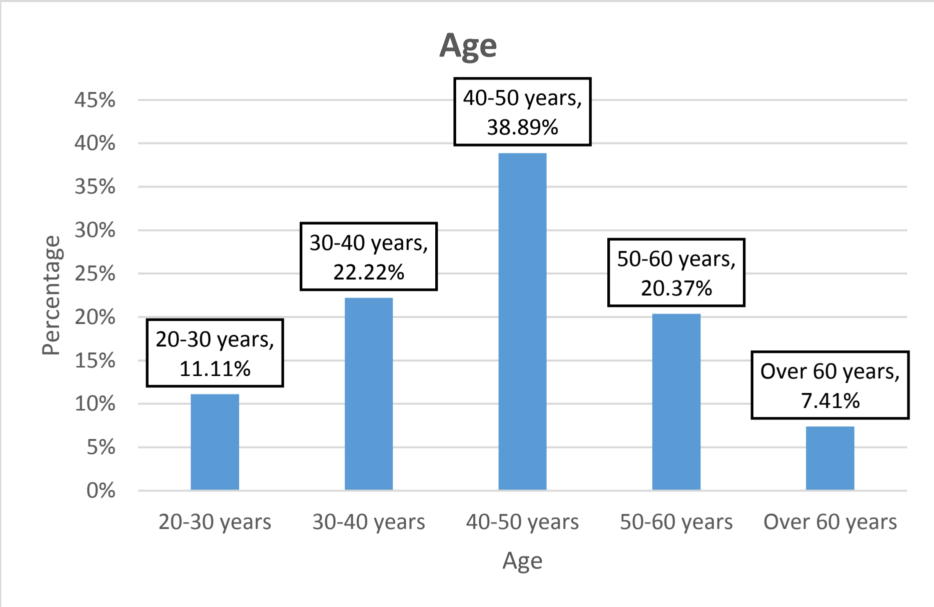

Figure 4.48: Q1_Age of Participants of the Storage Unit

The second question is an optional question which asked the participants to write down their occupation. 45 responses were received. Different occupations were identified like labour analysts, technicians, specialists, engineers, operators, supervisors, drivers and safety officers. These results are shown in Figure 4.49.

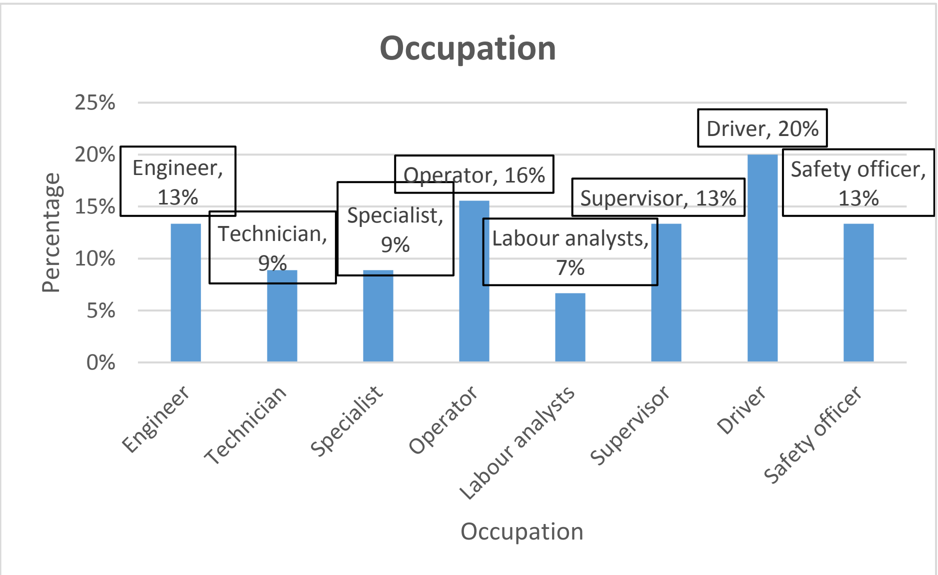

Figure 4.49: Q2_Occupation of Participants of the Storage Unit

The third question in this section, the participants were asked to comment on their experience in O&G industry. Among the 54 respondents, (20.37%) were with 0-5 years of experience, (22.22%) were with 6-10 years of experience, (44.45%) were with 11-15 years of experience and (12.96%) were with more than 15 years of experience. The results of experience are presented in Figure 4.50.

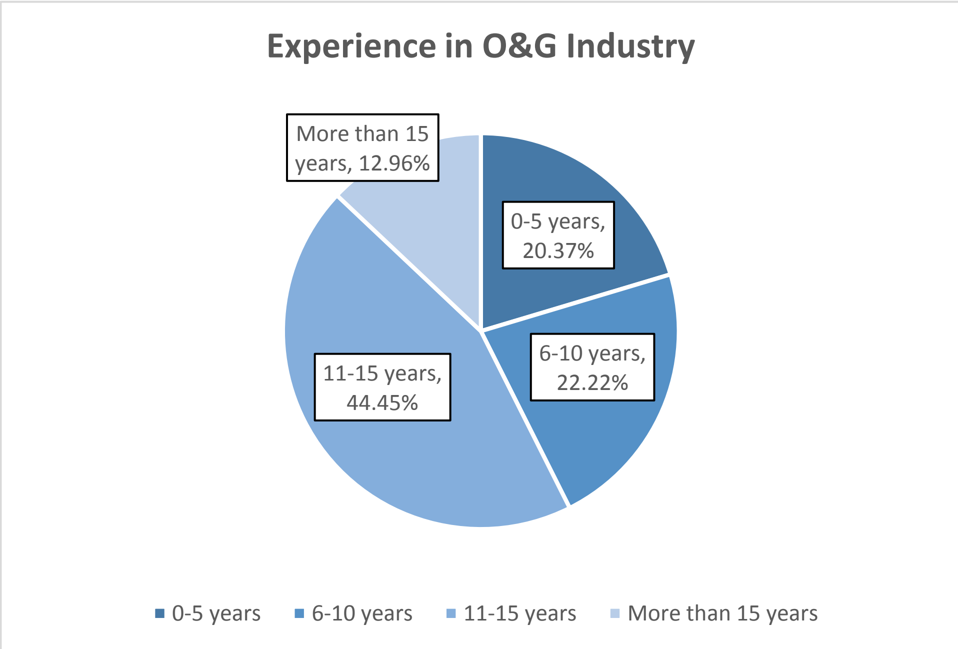

Figure 4.50: Q3_Experience in the Oil and Gas Industry of Participants of the Storage Unit

4.4.3.1.2 Workplace information

The second section provides the main characteristics of the workplace. In this section, respondents were asked 8 questions. In the first question, respondents were asked about the type of their work schedule. Fixed work schedule accounted for (22.22%) of respondents while shifts work schedule accounted for more than three quarters of respondents (77.78%). Figure 4.51 summarises that.

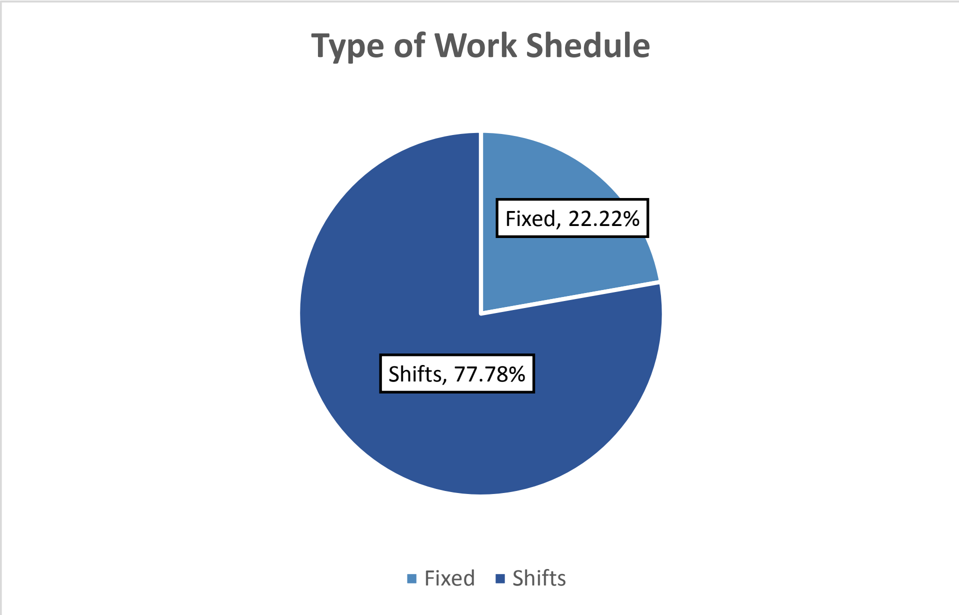

Figure 4.51: Q1_ Type of Work Schedule of Participants of the Storage Unit

In the second question, respondents were asked about their weekly working hours and the results showed that (68.52%) of respondents worked for 40-49 hours per week and (31.48%) of respondents worked for 50-59 hours per week. A summary for that is tabulated in Table 4.16.

Table 4.16: Q2_ Weekly Working Hours of Participants of the Storage Unit

Weekly Working Hours	Number of Responses	Percentage
40-49 hours	37	68.52%
50-59 hours	17	31.48%
Total	54	100.00%

In the third question, respondents had an optional question about their safety qualification. Two types of safety qualifications were gathered as firefighting certificate and safety induction course. In the fourth question, respondents were asked about the level of risk in their workplace. Figure 4.52 presents that the majority of respondents with (75.93%) agreed that their workplace has a high level of risk while the remaining percentage of (24.07%) responses indicated that their workplace has a medium level of risk.

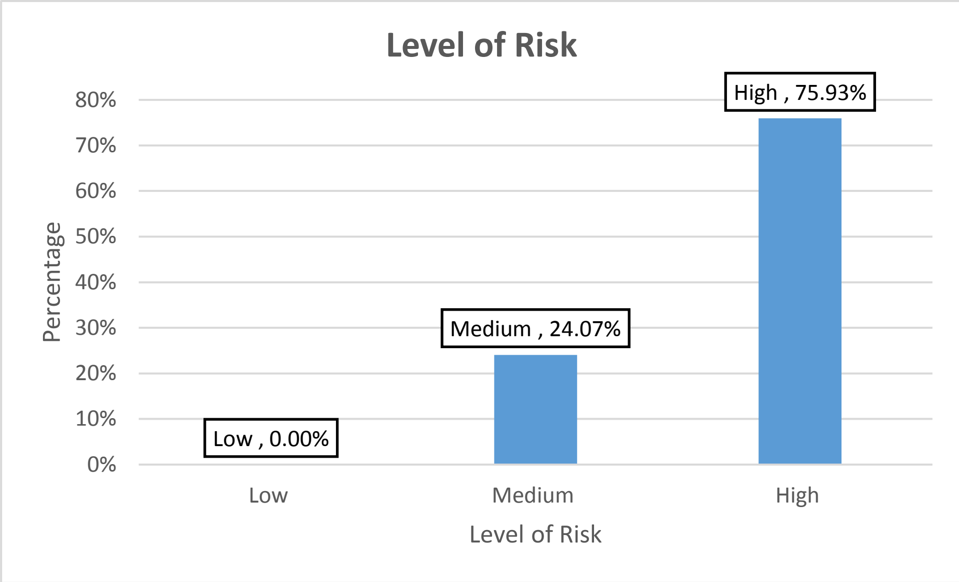

Figure 4.52: Q4_Level of Risk in the Storage Unit

In the fifth question, respondents were asked about the need of PPE while carrying out their job. A significant portion of respondents with (75.93%) selected 'Always' for the need of PPE whereas the remained portion of them with (24.07%) selected 'Sometimes' for the need of PPE in their job. These results are shown in Table 4.17.

Table 4.17: Need of Personal Protective Equipment in Job in the Storage Unit

Need of PPE	Number of responses	Percentage
Sometimes	13	24.07%
Always	41	75.93%
Total	54	100.00%

In the sixth question, respondents were asked about their work location whether it is indoor or outdoor and this information is presented in Figure 4.53. Only (38.89%) of respondents pointed that they dealt with outdoor work location while the remaining percentage of (61.11%) pointed that they dealt with indoor work location.

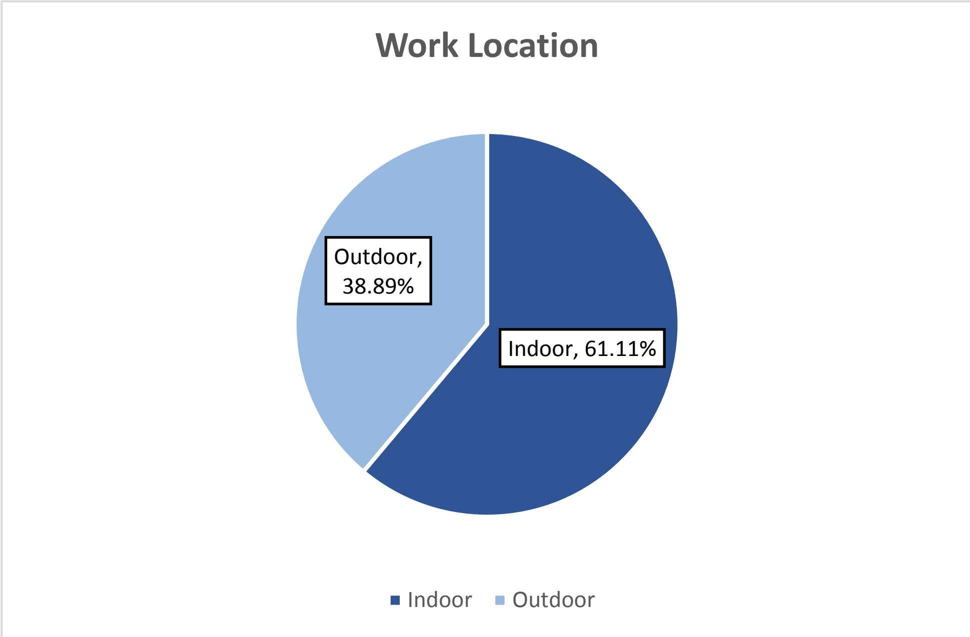

Figure 4.53: Q6_Work Location of Participants of the Storage Unit

In the seventh question, respondents were asked about the noise level in their workplace. A significant portion constituted the vast majority of storage unit's participants with (77.78%) agreed that the workplace has with high level of noise. Whilst the remaining percentages were for medium and low level of noise with (18.52%) and (3.70%) respectively as shown in Figure 4.54.

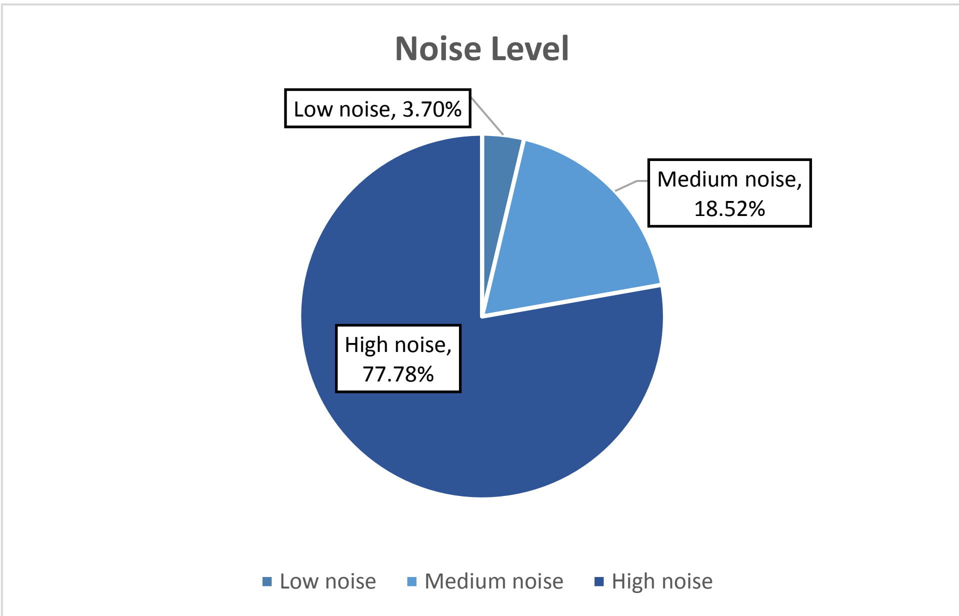

Figure 4.54: Q7_Noise Level in the Storage Unit

Lastly, in the eighth question, respondents were asked about the clarity of the communication language between different workers. Responses are represented in Figure 4.55. (53.70%) was for bad communication language, (40.74%) was for medium communication language and (5.56%) was for good communication language.

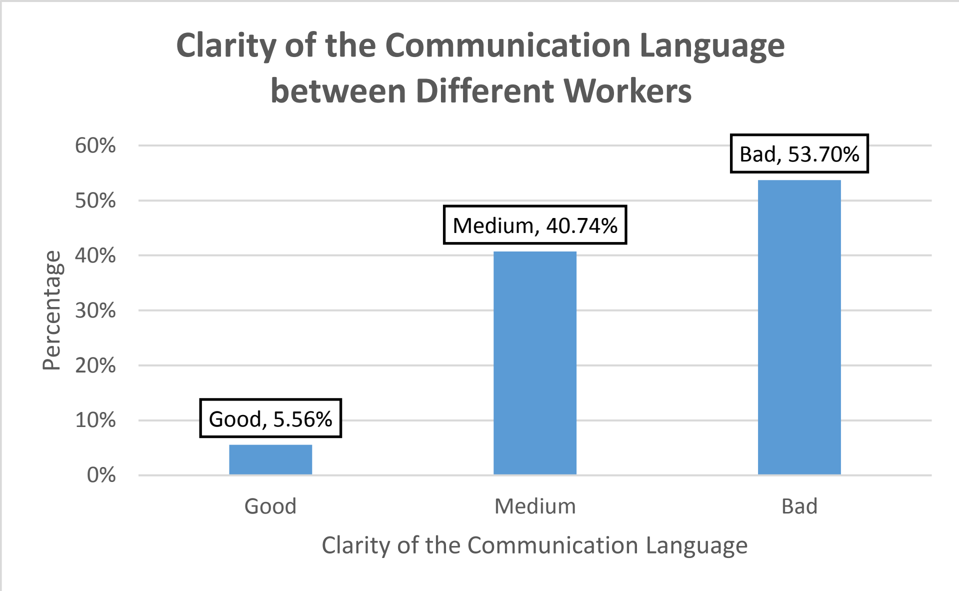

Figure 4.55: Q8_Clarity of the Communication Language between Different Workers in the Storage Unit

4.4.3.1.3 Opinions on Workplace

This section presents the judgments and opinions of the operational level of the storage unit against *Safety_regulation, Safety_implementation, Top_management, Safety_training, Safety_leadership, Communication and Accidents_reporting_system* constructs using five points Likert Scale. These opinions were analysed in SPSS through Spearman's Rank Order Correlation Coefficient and Mann-Whitney U Test. The results of the descriptive and inferential analyses are presented in the next sub-sections.

4.4.3.1.3.1 Results of the Descriptive Analysis

54 responses from the storage unit were analysed using the SPSS (version 24.0) to critically evaluate *Safety_regulation*, *Safety_implementation*, *Top_management, Safety_training, Safety_leadership*, *Communication* and *Accidents_reporting_system* (constructs) in this unit. The means, medians, modes and standard deviations pertaining to these seven constructs of interest in the storage unit are presented in Table 4.18.

Table 4.18: Descriptive Statistics for the Seven Constructs in the Storage Unit

Item	Mean	Median	Mode	Standard Deviation	Result
Safety_regulation	2.31	2.20	2.00	0.485	**Disagree (a challenge)**
Safety_implementation	2.52	2.12	1.50	1.062	**Disagree (a challenge)**
Top_management	3.47	3.67	3.67	1.207	**Agree**
Safety_training	2.34	1.67	1.33	1.231	**Disagree (a challenge)**
Safety_leadership	2.51	2.25	2.25	0.912	**Disagree (a challenge)**
Communication	2.85	2.75	2	0.902	**Neither**
Accidents_reporting_system	2.38	2.33	2.33	0.640	**Disagree (a challenge)**

The highest mean was for *Top_management* while the lowest mean was for *Safety_regulation*. By comparing the weighted mean level of agreement on the scores of the first column (Mean) and the theoretical average in Table 4.5, the last column (Result) in Table 4.18 was generated in order to give a conclusion on the level of agreement on the seven constructs. Thus, the scores in the last column (Result) express the opinions of the storage unit's respondents. Results reveals that the respondents of the storage unit agreed that *Safety_regulation, Safety_implementation*, *Safety_training*, *Safety_leadership* and *Accidents_reporting_system* are only challenges related to human error accidents.

4.4.3.1.3.2 Results of the Inferential Analysis

An examination of the scatterplots (not presented) suggested that there is a linearity between the resulted five challenges. The presence of linearity permitted the use of correlation coefficients. According to the distribution of scores underlying these challenges, the standardized skewness coefficients and the standardized kurtosis coefficients revealed serious departures from normality for these challenges. Results were outside of the limits of normality and were indicative of serious departures from normality (Onwuegbuzie & Daniel, 2002; Cramer & Howitt, 2004; Doane & Seward, 2011). Results from Shapiro & Wilk's test (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots concluded that the scores of these five challenges in the storage unit were not normally distributed (Cramer & Howitt, 2004; Doane & Seward, 2011).

4.4.3.1.3.2.1 Spearman's Rank Order Correlation Coefficient

Accordingly, a nonparametric procedure, the Spearman's rank order correlation coefficient was computed to assess the correlations between the five challenges. These correlations are reported in Table 4.19.

Table 4.19: Spearman's Rank Order Correlation Coefficient in the Storage Unit

			Safety_ regulation	Safety_ implementation	Safety_training	Safety_leadership	Accidents_ reporting_ system
Spearman's rho	Safety_regulation	Correlation Coefficient	1	-.008	.835**	.733**	.158
		Sig. (2-tailed)	.	.957	.000	.000	.255
		N	54	54	54	54	54
	Safety_implementation	Correlation Coefficient	-.008	1	-.165	-.070	.118
		Sig. (2-tailed)	.957	.	.233	.616	.395
		N	54	54	54	54	54
	Safety_training	Correlation Coefficient	.835**	-.165	1	.656**	.141
		Sig. (2-tailed)	.000	.233	.	.000	.309
		N	54	54	54	54	54
	Safety_leadership	Correlation Coefficient	.733**	-.070	.656**	1	.306*
		Sig. (2-tailed)	.000	.616	.000	.	.025
		N	54	54	54	54	54

	Accidents_reporting_system	Correlation Coefficient	.158	.118	.141	.306*	1
		Sig. (2-tailed)	.255	.395	.309	.025	.
		N	54	54	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Using the rule of thumb of Hinkle et al. (2003) for interpreting the size of a correlation coefficient, the Spearman's rho revealed statistically significant low, moderate and high positive correlations. The effect size of this relationship was small (Cohen, 1988). There was significantly a low positive correlation between *Accidents_reporting_system* and *Safety_leadership* ($rs[54] = 0.306$, $p < 0.025$). By squaring the correlation coefficients indicated by how much the variance in the percent of the first challenge was explained by the presence of the second challenge. For example, 9.3% of the variance in the percent of *Accidents_reporting_system* was explained by the presence of *Safety_leadership*. Moreover, there was significantly a moderate positive correlation between *Safety_leadership* and *Safety_training* ($rs[54] = 0.656$, $p < 0.001$) and this indicated that 43% of the variance in the percent of *Safety_leadership* was explained by the presence of *Safety_training.*

However, there were significant high positive correlations between

- *Safety_training* and *Safety_regulation* ($rs[54] = 0.835$, $p < 0.001$);
- *Safety_leadership* and *Safety_regulation* ($rs[54] = 0.733$, $p < 0.001$);

By squaring the correlation coefficient, 70% of the variance in the percent of *Safety_training* was explained by the presence of *Safety_regulation* whereas, 54% of the variance in the percent of *Safety_leadership* was explained by the presence of *Safety_regulation*. Overall, there were significantly four positive correlations. The percent of variance explained by each variable ranged between 9.3% and 70%. The strongest correlation coefficient was for the *Safety_training* and *Safety_regulation*: $rs(54) = +0.835$, $p < 0.001$. The weakest correlation coefficient was for the *Accidents_reporting_system* and *Safety_leadership*: $rs(54) = +0.306$, $p < 0.025$.

4.4.3.1.3.2.2 Mann-Whitney U Test

As the scores of the five challenges in the storage unit were not normally distributed, a nonparametric test (Mann-Whitney U test) was conducted in the storage unit to examine whether fixed schedule employees and shift schedule employees have a similar agreement on each of the five challenges. The results of this test are shown in Table 4.20. The null hypothesis was:

H0: "The mean agreement of fixed schedule employees and shift schedule employees are equal in the storage unit."

Table 4.20: Results of Mann-Whitney U for Work Schedule in the Storage Unit

Item	Work Schedule	N	Mean Rank	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)	Result
Safety_regulation (different shape)	**Fixed**	12	6.50	0.000	-5.278	0.001	**Reject H0**
	Shift	42	33.50				
Safety_implementation (same shape)	**Fixed**	12	22.75	195.000	-1.211	0.226	**Accept H0**
	Shift	42	28.86				
Safety_training (different shape)	**Fixed**	12	12.42	71.000	-3.808	0.001	**Reject H0**
	Shift	42	31.81				
Safety_leadership (different shape)	**Fixed**	12	6.71	2.500	-5.238	0.001	**Reject H0**
	Shift	42	33.44				
Accidents_reporting_system (different shape)	**Fixed**	12	22.46	191.500	-1.295	0.195	**Accept H0**
	Shift	42	28.94				

Based on the results from the Mann-Whitney U test in the storage unit in Table 4.20 regarding the agreement that safety regulation is a challenge to human error accidents in the storage unit, results showed a significant difference (U = 0.0, p = 0.001) between fixed schedule employees and shift schedule employees. In this case, a low value of U= 0.0 was produced due to a large difference between the two samples and it means that there was the maximum possible difference between fixed work schedule sample and shift work schedule sample. Thus, the mean rank for shift schedule employees was 33.50 compared to 6.50 for fixed schedule employees suggesting that those of shift schedule consider safety implementation more as a challenge. The effect size was large (0.72) (Cohen, 1988).

Then, regarding the agreement that safety implementation is a challenge to human error accidents in the storage unit, results revealed that the distributions of fixed schedule employees and shift schedule employees were equal (U = 195.0, p = 0.226). This means that there was no difference between the agreements on safety implementation challenge of both work schedule groups. The effect size was small (0.16) (Cohen, 1988). While regarding the agreement that safety training is a challenge to human error accidents in the storage unit, results also revealed a significant difference (U = 71.0, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 31.81 compared to 12.42 for fixed schedule employees suggesting that those of shift schedule consider safety training more as a challenge. The effect size was medium (0.52) (Cohen, 1988).

As well as, regarding the agreement that safety leadership is a challenge to human error accidents in the storage unit, results also revealed a significant difference (U = 2.5, p = 0.001) between fixed schedule employees and shift schedule employees. The mean rank for shift schedule employees was 33.44 compared to 6.71 for fixed schedule employees suggesting that those of shift schedule consider safety training more as a challenge. The effect size was large (0.71) (Cohen, 1988). Finally and regarding the agreement that accidents reporting system is a challenge to human error accidents in the storage unit, results revealed that the distributions of fixed schedule employees and shift schedule employees were equal (U = 191.5, p = 0.195). This means that there was no difference between the agreements on accidents reporting system challenge of both work schedule groups. The effect size was small (0.18) (Cohen, 1988).

Apart from all that, a Mann-Whitney U test was conducted also in this unit to examine whether indoor employees and outdoor employees have a similar agreement on each of the five challenges in the storage unit. The results of this test are presented in Table 4.21. The null hypothesis was:

H0: "The mean agreement of indoor employees and outdoor employees are equal in the storage unit."

Table 4.21: Results of Mann-Whitney U for Work Location in the Storage Unit

Item	Work Location	N	Mean Rank	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)	Result
Safety_regulation (different shape)	**Indoor**	33	18.35	44.500	-5.394	0.001	**Reject H0**
	Outdoor	21	41.88				
Safety_implementation (different shape)	**Indoor**	33	32.70	175.000	-3.108	0.002	**Reject H0**
	Outdoor	21	19.33				
Safety_training (different shape)	**Indoor**	33	17.14	4.500	-6.136	0.001	**Reject H0**
	Outdoor	21	43.79				
Safety_leadership (different shape)	**Indoor**	33	20.15	104.000	-4.342	0.001	**Reject H0**
	Outdoor	21	39.05				
Accidents_reporting_system (different shape)	**Indoor**	33	26.21	304.000	-0.776	0.438	**Accept H0**
	Outdoor	21	29.52				

Based on the results from the Mann-Whitney U test in the storage unit in Table 4.21 regarding the agreement that safety regulation is a challenge to human error accidents in the storage unit, results showed a significant difference (U = 44.5, p = 0.001) between indoor employees and outdoor employees. The mean rank for outdoor employees was 41.88 compared to 18.35 for indoor employees suggesting that those of outdoor work location consider safety implementation more as a challenge. The effect size was large (0.73) (Cohen, 1988). Then, regarding the agreement that safety implementation is a challenge to human error accidents in the storage unit, results also revealed a significant difference (U = 175.0, p = 0.001) between indoor employees and outdoor employees. The mean rank for indoor employees was 32.70 compared to 19.33 for outdoor employees suggesting that those of indoor work location consider safety implementation more as a challenge. The effect size was small (0.42) (Cohen, 1988).

While, regarding the agreement that safety training is a challenge to human error accidents in the storage unit, results also revealed a significant difference (U = 4.5, p = 0.001) between indoor employees and outdoor employees. The mean rank for outdoor employees was 43.79 compared to 17.14 for indoor employees suggesting that those of outdoor work location consider safety training more as a challenge. The effect size was large (0.84) (Cohen, 1988). As well as, regarding the agreement that safety leadership is a challenge to human error accidents in the storage unit, results revealed a significant difference (U = 104.0, p = 0.001) between indoor employees and outdoor employees. The mean rank for outdoor employees was 39.05 compared to 20.15 for indoor employees suggesting that those of outdoor work location consider communication more as a challenge. The effect size was large (0.60) (Cohen, 1988). Finally and regarding the agreement that accidents reporting system is a challenge to human error accidents in the storage unit, results revealed that the distributions of indoor employees and outdoor employees were equal (U = 304.0, p = 0.438). This means that there was no difference between the agreements on accidents reporting system challenge of both work location groups. The effect size was small (0.11) (Cohen, 1988).

Overall, a Mann-Whitney U test indicated that the agreement on three challenges related to human error accidents (*Safety_regulation, Safety_training* and *Safety_leadership)* in the storage unit was significantly greater for shift schedule employees than for fixed schedule employees. Two exceptions were presented which were no significant difference between shift schedule employees and fixed schedule employees on the agreement that *Safety_implementation* is a challenge to human error accidents and on the agreement that *Accidents_reporting_system* is a challenge to human error accidents. Additionally, this test indicated that the agreement on three challenges (*Safety_regulation, Safety_training* and *Safety_leadership)* in the storage unit was significantly greater for outdoor employees than for indoor employees. However, results showed that the agreement on *safety_implementation* in the storage unit was significantly greater for indoor employees than for outdoor employees. Besides, results revealed that there was no significant difference between indoor employees and outdoor employees on the agreement that *Accidents_reporting_system* is a challenge to human error accidents.

The next section presents the cross-case analysis for the qualitative data (semi-structured interview) within the three units and the cross-case analysis for the quantitative data (questionnaire survey) within the three units.

4.5 Cross-case Analysis

The analysis of the three cases individually is presented in the previous sections by identifying the current OHS framework in O&G industry, human error accidents and its related challenges in O&G industry in Bahrain, adapted best safety practices and the need for safety strategy in O&G industry in Bahrain. This section extends the scope of the previous sections to analyse the data across cases. According to Yin (2014), the cross-case analysis is among five techniques of case-study analysis that are used widely within multiple-case studies. Yin (2014) also pointed that a cross-case analysis serves to discover whether the selected cases replicate or contrast with each other. Thus, the analysis in this section tends to present possible theoretical generalisations and exploring common variables within these cases.

4.5.1 Cross-case Analysis for the Qualitative Data

Studies of OHS and safety in workplaces indicted the importance of developing a robustness one that is continuously aligned with the need of workplace. Jonathan & Mbogo (2016) stated that OHS concern is legitimate in all types of human enterprise. O&G industry is one of workplaces that needs a robustness OHS framework based on the risky nature of this industry. This framework is developed in workplaces to ultimately ensure an effective level of OHS in workplaces for all employees and stakeholders, improve the OHS performance, prevent deaths and reduce the potential for work-related accidents and injuries. It envisions a flexible framework that can expand and evolve to control OHS risks and to address issues confronted by rapidly changing workplaces.

The judgments and opinions of the managerial level in each case regarding the current OHS framework within O&G industry in Bahrain were identified previously. Table 4.22 is a summary for each feature regarding this OHS framework that has been identified by the majority of each of the three cases (≥3).

Table 4.22: Cross-case Analysis for Overview on OHS Framework

Overview on OHS Framework	**Cases**		
	Refining Unit	**Distributing Unit**	**Storage Unit**
Existing OHS framework			
Complies with national and international regulations and standards			✓
It is better than last 5 years		✓	
Needs a coordinator	✓		
Needs improvement in comparison with the rapid changes	✓	✓	✓
Needs specific regulations for O&G industry	✓		
Risk level			
Preventive measures, techniques and control		✓	✓
Based on the nature of each workplace	✓	✓	
Risk is everywhere	✓	✓	✓
Safety in company A			
Safety record is critical		✓	
We have a good safety achievement			✓

Based on the results in the above table, different results were revealed to describe this existing OHS framework. From the point of view of the storage unit, OHS framework complies with the internal and external regulatory bodies' requirements. According to Simon (2014), ensuring that all designs and critical safety specifications in storage unit are aligned with the regulatory requirement has become a priority in the storage unit. This is because any tank failure might result in accidents and fatalities and cause a large environment pollution, heat radiation, fires and explosions (Simon, 2014; Taylor, 2003). Results of distributing unit also showed that, the current OHS framework is better than the last five years. However, results indicated that this framework requires several improvement efforts. The refining, distributing and storage units agreed that it needs more improvement efforts to address the rapid changes in the workplace, market and regulations. This supports the argument of Watson & Vandervell (2006) that pointed that as the O&G industry operates in a global marketplace,the refining and other units requires always meeting tighter product standards specifications and more stringent environmental standards. Moreover, results of the refining unit pointed that this framework does not only needs a coordinator authority or party that is responsible for ensuring the effectiveness of the OHS framework and regulations in O&G industry but also it needs dedicated regulations that match the nature of this industry, materials and tasks and address gaps and requirements in this industry. In this regard, Yaqoob et al. (2019) have concluded that there is a lack of legislations and regulations on energy sector in Bahrain which limits the robustness of evaluation reports in this sector.

On top of that, all units agreed that risk exists in O&G industry anywhere and can lead to a large accident at sudden. However, the distributing and storage units pointed that O&G industry adapts a number of risk prevention and control measures and techniques to assess, manage and control risks in order to reach an acceptable level of risk. According to the storage unit, Simon (2014) expressed that storage unit requires a continuous inspection and a unique maintenance in order to mitigate risks in tanks. Besides, the refining and distributing units agreed that the level of risk is linked strongly to the nature of each unit. This finding supports the view of Osabutey, Obro-Adibo, Agbodohu & Kumi (2013), who argued that the refining unit is vulnerable to various hazards particularly from the used chemicals and the high temperature in this unit. Adding further support to this view, Markussen (2003) argued that the refining unit in O&G industry is a highly risky workplace as it exposes employees to certain risky chemicals and substances like benzene and Naturally Occurring Radioactive Material. Another argument proposed by Simon (2014) supports that in the context of storage unit. He indicated that as this unit deals with oil, tanks and pressure, the level of risk in this unit depends heavily on the amount of oil and pressure. Thus, huge amount of oil and pressure may cause spills or leaks.

On the other hand, regarding the specific nature of the distributing unit, Taylor (2003) pointed that this unit has a unique characteristic which is the liquid fire in processing equipment. He stressed that this type of fire which is resulted from typically leaks from flanges, pump packings, broken low gage valves, corrosion holes, burst vessels, etc. or overflow from tanks and drains could lead to costly accidents. Lastly, only distributing unit agreed that safety is a critical and important factor in Company A whereas only storage unit agreed that Company A has a good safety achievement and a good historical safety record.

Table 4.23 lists the features of human error accidents that have been identified by the majority of each of the three cases (≥3).

Table 4.23: Cross-case Analysis for Human Error Accidents

Human Error Accidents	Cases		
	Refining Unit	Distributing Unit	Storage Unit
Definition			
Low safety behaviour	✓		
Negative act	✓	✓	✓
Harmful event leads to loss	✓	✓	✓
Examples of Human error accidents			
Lack of judgment	✓		
Shortcut			✓
Loss of focus	✓	✓	
Overconfidence	✓	✓	✓
Carelessness			✓
Ignoring importance of wearing PPE	✓	✓	✓
Challenges related to human errors accidents			
Accidents reporting system	✓	✓	✓
Communication	✓		

Role of safety leadership	✓	✓	
Role of top management			✓
Safety behaviour	✓	✓	✓
Safety culture	✓		
Safety implementation	✓		
Safety training	✓	✓	✓
Recommendations			
OHS regulations and orders		✓	
Safety leadership			✓
Employee engagement		✓	
Safety culture			✓
Safety authority	✓		✓
New technology	✓		✓
Accidents reporting system	✓	✓	✓
Safety awareness	✓		
Human resource management	✓	✓	✓
Safety compliance	✓		
Safety training programme	✓	✓	✓
Safety research, development and investment		✓	
Safety competency		✓	
Communication		✓	

Results in Table 4.23 revealed that all units defined a human error accident similarly as a negative act or action performed by a worker that leads to several types of losses and bad consequences on the worker, equipment, machine, workplace and the overall environment. In this regard, Wiegmann et al. (2005) argued that as errors represent the mental or physical activities of people that fail to reach the desired outcome; therefore, by considering human being nature, it is not surprising that they make errors and perform unsafe acts. As well as, the refining unit viewed this type of accidents as a low safety behaviour. In addition, this view was clearly reflected by the examples obtained from these units. For example, all the three units agreed that overconfidence and ignoring the importance of wearing PPE are the most common examples in O&G industry in Bahrain. Although O&G industry is a workplace that is restricted by several OHS regulations and rules, overconfidence happens. Hoffman & Burks (2017) pointed that overconfidence occurs when the worker believes in himself to the point where he thinks that he cannot fail under any conditions. Thus, overconfidence and ignoring the importance of wearing PPE are ranked as the first top examples. Meikle, Tenney & Moore (2016) concluded that although overconfidence is present and influences the workplaces, teamwork, warnings and feedback can reduce or mitigate it. While regarding ignoring the importance of wearing PPE, The Oil Companies International Marine Forum (OCIMF) & International Association of Independent Tanker Owners (INTERTANKO) (2018) explained that all workers should be responsible of taking all the required and necessary precautions equipment, materials, clothing and devices that are provided by the employer in order to protect of themselves and others.

Furthermore, based on the refining and distributing units loss of focus is ranked as the second example in O&G industry in Bahrain. This can be translated by the nature of each unit and as the refining unit is characterised by a high level of noise and vibration (the physical hazards), this might affect negatively the focus of workers (Ohi Asikhia & Emenike, 2013). Safe Work Australia (2015) reported that noise and vibration are the most common self-reported exposures in the manufacturing industry. One the other hand, only the refining unit indicated that lack of judgment is another example. Besides, only the storage unit indicated that shortcut and carelessness are other scenarios of human error accidents. Thus, lack of judgment, shortcut and carelessness are ranked as the third examples of this type of accidents.

Although the workplaces in the storage unit are very complex and dangerous and have various safety requirements, some employees tempt to take a shortcut while performing a task in order to do it in a faster way but not in a proper and safer one. HSE (2003) pointed that workers should follow the predefined procedures and prevent shortcuts by dealing with rubble rather than taking shortcuts. In this regard, OCIMF & INTERTANKO (2018) indicated that workers decide to make shortcuts and ignore procedures during the fulfilment of their task because they are unsatisfied with the current working conditions. On top of that, Safe Work Australia's (2015) reported that the 'worker being careless' is one of the top three most frequently nominated causes of accidents in the manufacturing sector in 2014. In this case, the worker is not following the written safe procedures appropriately. Robens (1972) developed the traditional approach to safety in the workplace called 'careless worker' model.

This model assumed that the majority of accidents in the workplaces were resulted from employee's failure to take safety seriously, or failing to protect themselves. Van Houten (2012) concluded that human errors like carelessness can be avoided by enforcing safety in workplaces through two things. The first one is through regulating the working conditions and environment people have to work in and the second one is through controlling risks at work.

The results in Table 4.23 also present the identified challenges related to human error accidents. These challenges are drawn clearly in Figure 4.56 to present the level of consensus between the three units regarding each challenge.

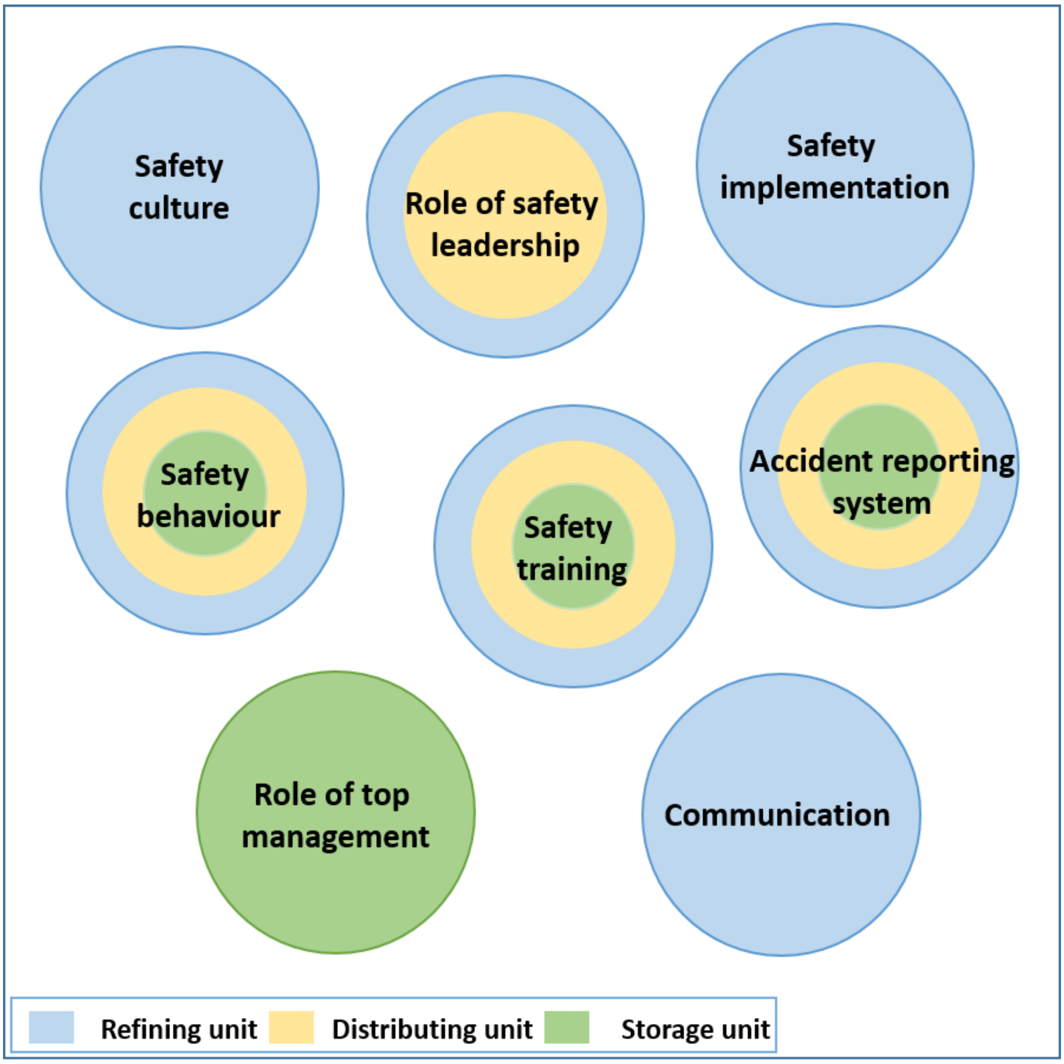

Figure 4.56: The Identified Challenges Related to Human Error Accidents from Cross-case Analysis

A wide range of challenges was found with different degree of consensus among the three units. A high degree of consensus from all units was accounted for accidents reporting system, safety behaviour and safety training. Based on HSA (2016), a successful accidents reporting system should clearly understand the prevalence and trends of specific accident types depending on up-to-date and reliable information. Insufficient accidents reporting system is interpreted as there is no adequate handling for the critical situations in which the root causes remain ambiguous and the accurate statistics are missed. In addition, it means that accidents are not properly investigated, corrective actions are not taken place, feedbacks are not maintained and lessons learned are not shared properly. As well as, De Faria Nogueira, Luiz, Quelhas, França, Meiriño & Mosca Cunha (2015) argued that encouraging a safe behaviours in the daily work of the workplaces strongly maintain a sustainable decreasing in the accident rate. In addition, they argued that a scheduled training programme should be designed for all employees and should embed all important safety issues, changes and rules. Poor safety training is characterised by two important characteristics. The first one is, poor training quality which means that the proposed training course is not delivering the required skills development. Therefore, sometimes some training courses were not satisfying the required improvement. The second one is, missing up-to-date material for the training courses.

After that, a lower degree of consensus from the refining and distributing units was accounted for the role of safety leadership. If an effective leadership does not exist at any workplace, a poor safety performance will be achieved. Zuofa & Ocheing (2017) concluded that the role of safety leadership could never be over emphasised in O&G industry. In addition, they expressed that an effective safety leadership can decrease human errors and accident rate in this industry by encouraging followers to work harder and efficiently and strengthening workers' safety performance responsibility. Based on that, developing and maintaining the role of safety leadership is important to decrease accidents and to stimulate safety among personnel.

Further, the refining unit pointed that communication, safety culture, and safety implementation are also challenges related to human error accident. In this regard, Salminen (2011) found that communication is comely a challenge in the workplaces that have a wide range of foreign workers. As Leonard, Graham & Bonacum (2004) explained that an effective communication positively contributes to the delivered safety quality; therefore, O&G industry should build a strong communication. Additionally, Osabutey et al. (2013) pointed that developing countries confront with the complexity of implementing the risk assessment and control measures in the refining unit. However, de Faria Nogueira et al. (2015) indicated that the OHS performance is strongly associated with safety culture and safety implementation in workplaces. Apart from that, only the storage unit agreed that the role of top management is a challenge to this type of accidents. This can be defined by the unit nature in term of complexity and high risk.

Overall, there are eight challenges related to human error accidents based on the point of view of managerial level of these three units. These challenges are safety bahaviour, safety training, accidents reporting system, role of safety leadership, safety culture, safety implementation, communication and role of top management.

Lastly, Table 4.23 presents the recommendations that are collected across the three units. These recommendations are presented clearly in Figure 4.57 to show the level of consensus between the three units regarding each recommendation.

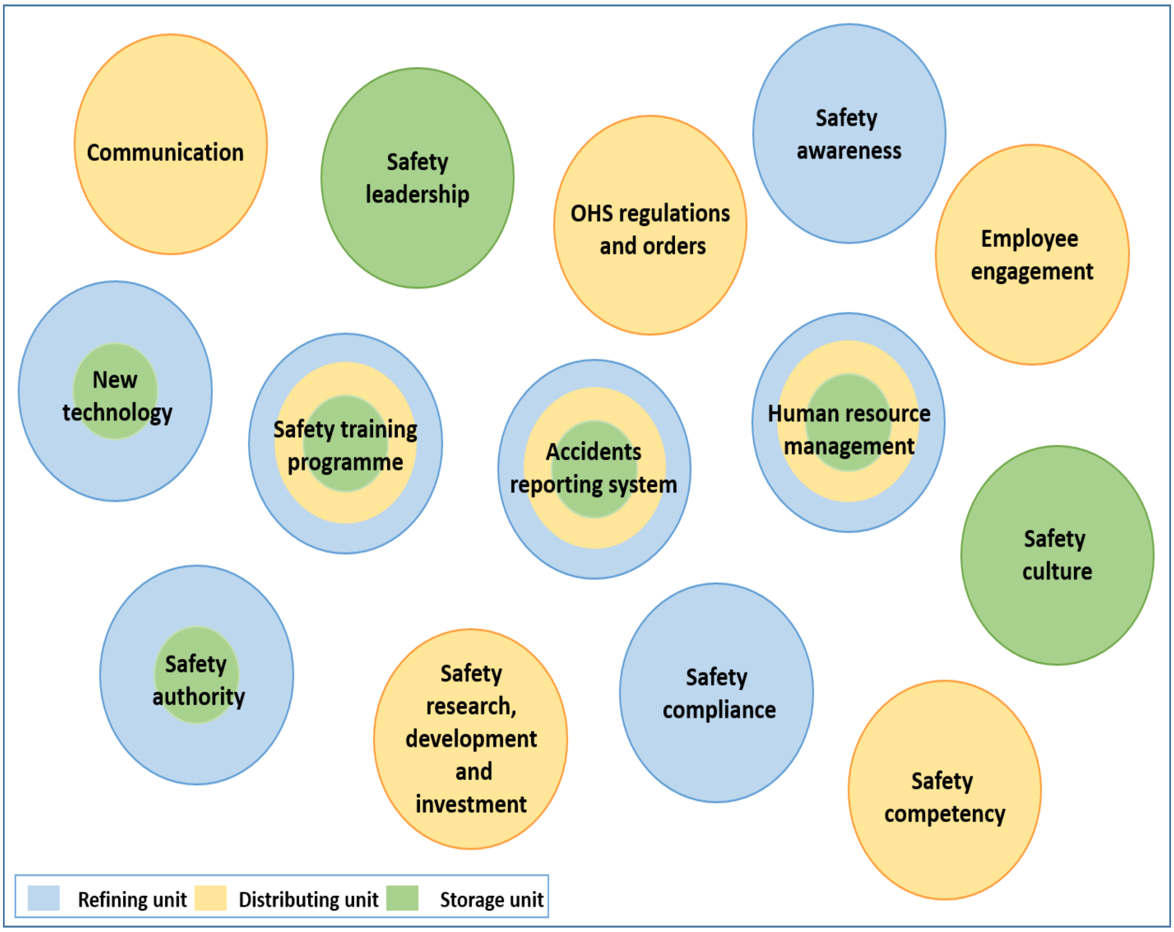

Figure 4.57: The Identified Recommendations to Overcome Challenges Related to Human Error Accidents from cross-Case Analysis

A high degree of consensus from all units was accounted for accidents reporting system, human resource management and safety training programme. All the three units pointed the key role of these three recommendations in improving the overall OHS performance and in reducing the potential of human error accidents. Then, a lower degree of consensus from the refining and storage units was accounted for deflecting attentions to the importance of building a safety authority and introducing new technologies in order to overcome the previous challenges. However, different recommendations were identified individually by each unit based on the current situation of each. As an error in the refining unit could lead to a huge impact on the economy and environment (Shrivastava, 1995), more additional recommendations were suggested by the interviewees. For example, they recommended that addressing the issues related to safety awareness of workers and safety compliance in the workplace will effectively assist in tackling these challenges. The report of OHS Insider (2012), Canada's leading source of guidance on compliance with the OHS laws on O&G industry, concluded that regulations and orders in O&G industry should address the safety matters and hazards specifically to this industry and should be consistent to some degrees with the nature of O&G industry.

As the distributing unit deals with distributing the final products through pipelines under a high speed and high pressure, it is too difficult to control or knock off any explosion due to the high flowability of the O&G (Taylor, 2003). Therefore, further recommendations were gathered to address the current challenges and reduce human error accidents. These recommendations are related to OHS regulations and orders, employee engagement, safety research, development and investment, worker’s safety competency and communication. PricewaterhouseCoopers (PwC) (2017) indicated that as the distributing unit distributes the final products of oil and gas to the customers over sometime long distances, therefore, it is utmost important to meet the regulations regarding that and the predefined specifications and to have a strong external communication. Leonard et al. (2004) pointed that with high reliability fields the adapting of standardised tools and behaviours in workplaces will effectively enhance the communications and relations and reduce the level of risk. Finally, the storage unit recommended that building a positive safety culture and having a visible safety leadership help in overpowering these challenges.

Table 4.24 lists the adapted best safety practices that have been identified by the majority of each of the three cases (≥3).

Table 4.24: Cross-case Analysis for the Adapted Best Safety Practices

Adapted Best Safety Practices	**Cases**		
	Refining Unit	**Distributing Unit**	**Storage Unit**
Operational Excellence	✓	✓	
Solomon Fuels Study		✓	✓

Based on the analysed results in Table 4.24, the refining and distributing units agreed that O&G industry in Bahrain adapts a common international best safety practice which is the Operational Excellence. Additionally, the distributing and storage units agreed that Solomon Fuels Study is another important adapted best safety practices across the O&G industry in Bahrain. Operational Excellence tends to upraise the company's performance to the World Class level. It concerns on ensuring that the company is doing the right things and the right ways all the time. According to WHO (2012), identifying the suitable best practices requires judgement and prior analysis to evaluate several features like efficiency, effectiveness, relevance, sustainability and possibility of duplication, ethical soundness, the community and political commitment and the involvement of partners.

Table 4.25 lists the opinions regarding the need for safety strategy in O&G industry in Bahrain that have been identified by the majority of each of the three cases (≥3).

Table 4.25: Cross-case Analysis for the Need for a Safety Strategy

Need for a Safety Strategy	**Cases**		
	Refining Unit	**Distributing Unit**	**Storage Unit**
Yes, we need a safety strategy	✓	✓	✓
Yes, safety strategy and accurate implementation		✓	

Based on the results in Table 4.25, all three units agreed that safety strategy is a critical need to O&G industry in Bahrain especially after the recent largest well discovery in Bahrain. Nevertheless, the distributing unit agreed that O&G industry does not just need this strategy but instead it needs also an accurate and effective implantation for it by all interested levels and parties in the industry. In this regard, Watson & Vandervell (2006) indicated that the industrial safety strategy should be consistent with the government priorities and based on sound science with rigorous cost/benefit analyses. This means that the success of this strategy requires that government and all stakeholders continue working together to deliver this. However, Nichols, Walters & Tasiran (2007) pointed out the importance of regulations, orders, policies and innovative non-regulatory or regulatory strategies in workplaces.

According to Ernst & Young (2015a), safety strategy is required in workplace to keep balance in the system between numerous interests like sustaining effective balance of social, environmental and economic values and boosting economic development simultaneously. As O&G industry in Bahrain continues to develop, expand and evolve over the coming years, an effective safety strategy is required in order to continue protecting the worker, workplace and environment, assisting orderly development, searching for new solutions to support and enable innovation and managing tasks and activities to be performed with higher efficiency and effectiveness.

At this point, all results of cross-case analysis for the qualitative data are presented. The next section discusses the cross-case analysis for the quantitative data.

4.5.2 Cross-case Analysis for the Quantitative Data

O&G industry is one of the most hazardous industries and not surprising that OHS of workers and safety of workplace are critical issues in this industry. Although OHS issues have been prioritised in O&G industry for several years, still some risks are not treated appropriately in this industry and accidents occur. Workers should be aware of these risks and how to protect themselves within this industry. Accordingly, to develop any improvement in this industry, it is important to hear from workers and involve their judgments.

In this section, the responses of the operational level of each section in the questionnaire surveys from the three units are presented. Based on the questionnaire format, there were three sections which are participant background, workplace information and opinion on workplace in O&G industry in Bahrain. These judgments and opinions are showed in the next sub-sections.

4.5.2.1 Participants' Background

The profile data of the participants is presented in this section like age, position and experience of those respondents. Respondents were asked to comment on their age. Age results in Figure 4.58 showed that the majority of responses within the three units were between 40 and 50 years. Then, in the second stage, the ages were between 30 and 40. After that, the ages between 20 and 30 and between 50 and 60 were in the third stage with nearly the same results. Finally, the least responses of ages from the three units were over 60 years.

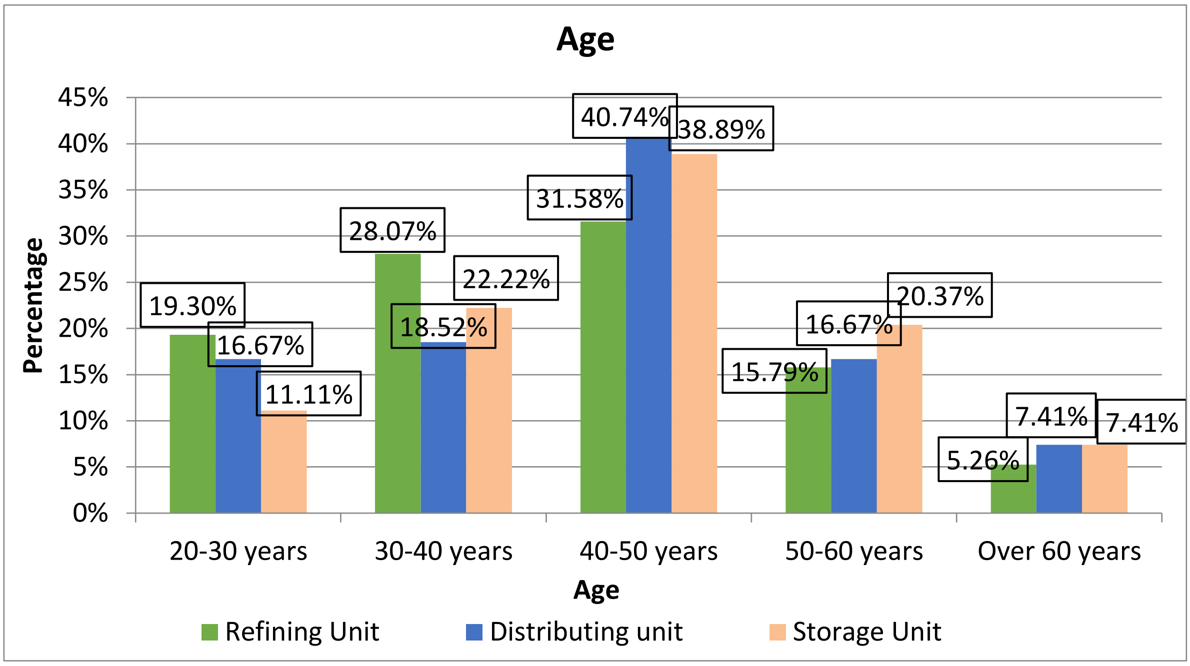

Figure 4.58: Cross-case Analysis for Age of Respondents

Then, occupation results are shown in Figure 4.59. A wide range of occupations was identified but the majority of the respondents within the three units were engineers, technichians, specialist and operators.

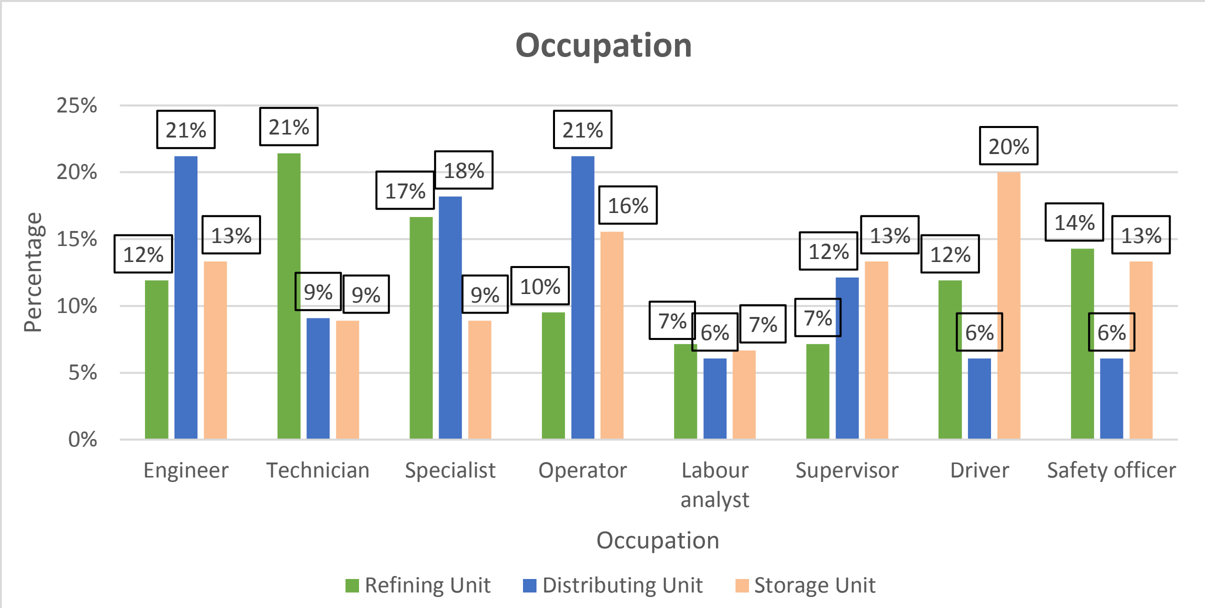

Figure 4.59: Cross-case Analysis for Occupation of Respondents

At the end of this section, the participants were asked to comment on their experience in O&G industry. Most of responses from the three units were with 11-15 years of experience. However, responses of 0-5 years of experience and 6-10 years of experience were similar. Nevertheless, respondents with more than 15 years of experience from all these units accounted the least percentages. The results of experience are presented in Figure 4.60.

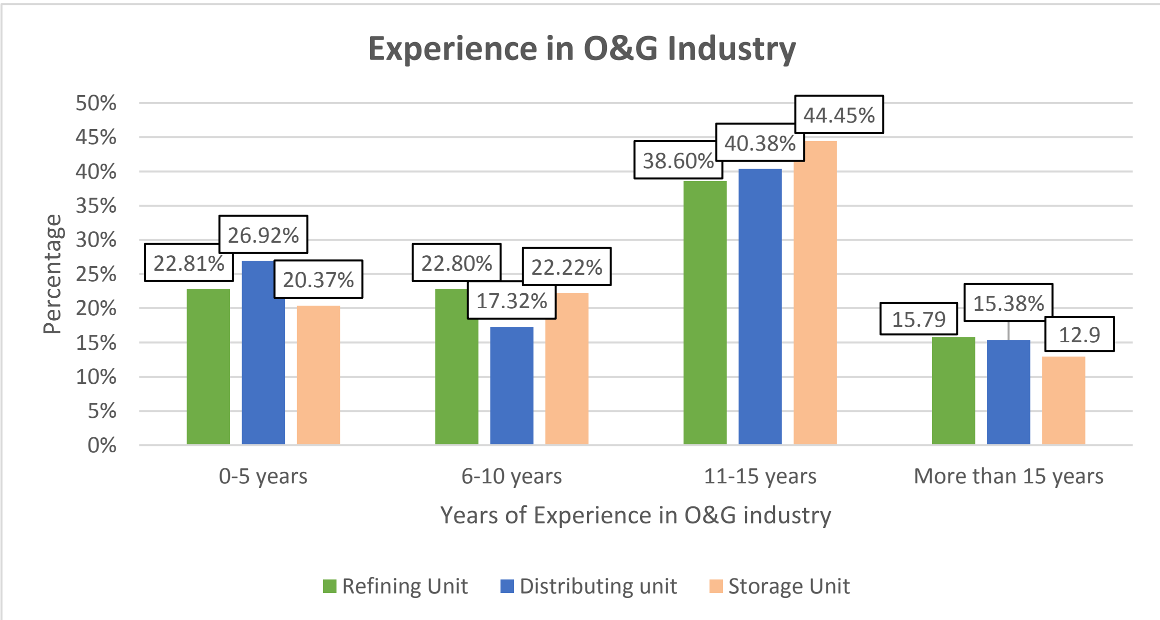

Figure 4.60: Cross-case Analysis for Experience of Respondents

4.5.2.2 Workplace information

The second section provides the main characteristics of the workplace. Regarding the work schedule type, more than (75%) of respondents of the refining, distributing and storage units asserted that they work with fixed work schedule while the remaining percentage of these units were accounted for shifts work schedule. Figure 4.61 summarises that.

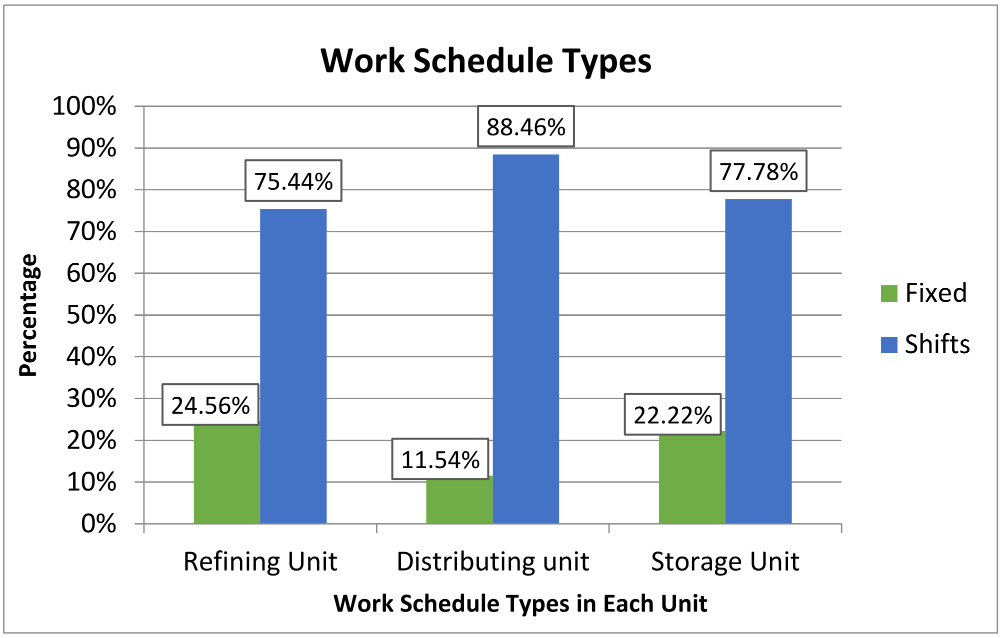

Figure 4.61: Cross-case Analysis for Work Schedule Types

Second, respondents were asked about their average weekly working hours and the results are showed in Figure. Figure 4.62 shows that more than two thirds of respondents of the three units indicated that they work around 40-49 hours a week while the remaining of respondents work between 50 and 59 hours weekly.

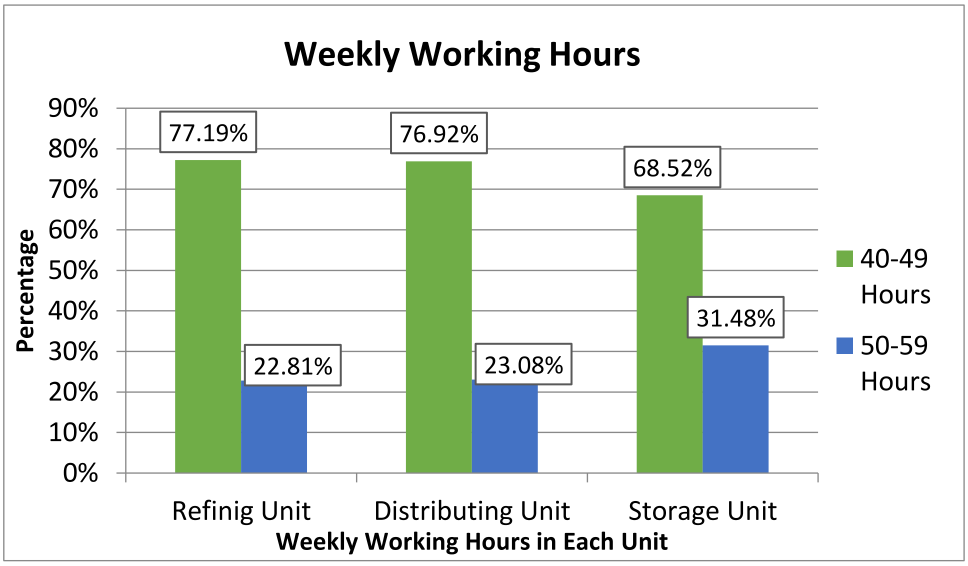

Figure 4.62: Cross-case Analysis for Weekly Working Hours

Third, respondents had an optional question about their safety qualification. Two types of safety qualifications were gathered as firefighting certificate and safety induction course. Fourth, respondents were asked about the level of risk in their workplaces. Figure 4.63 presents that the majority of respondents of the three units agreed that there is a high level of risk in their workplaces. Although no one from the three units described their workplaces as low risk, a small portion of respondents from each unit indicated that the risk level is medium.

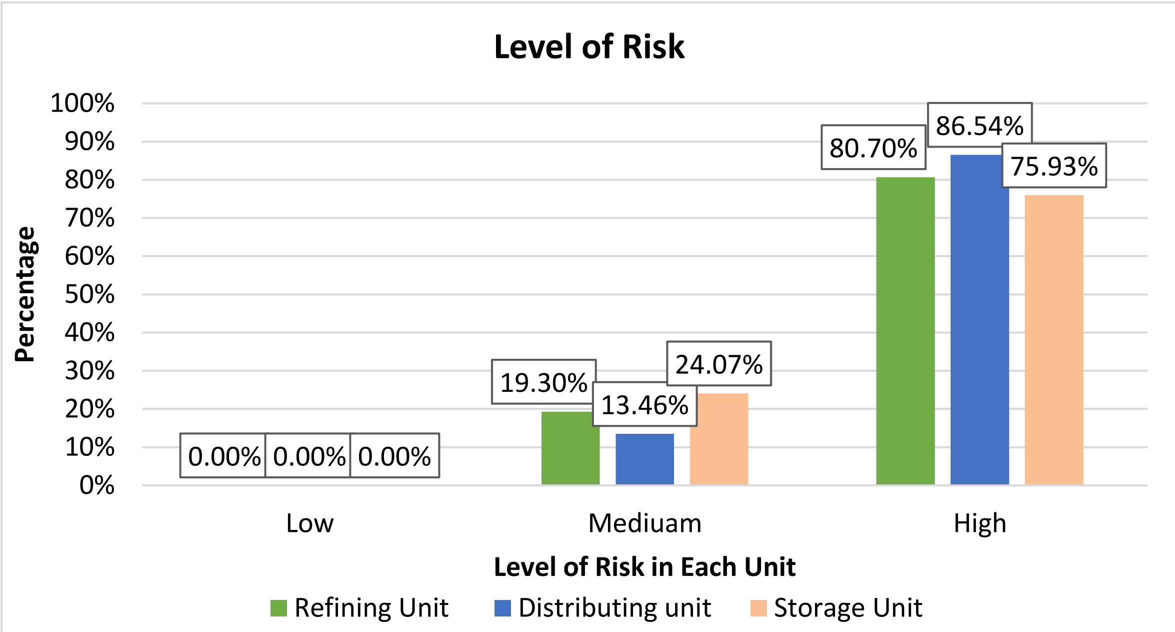

Figure 4.63: Cross-case Analysis for Level of Risk

Fifth, respondents were asked about the need of PPE while carrying out their tasks. Around (75%) of respondents from each unit agreed that PPE is always needed and it is considered as a critical prerequisite for carrying out their tasks. In contrast, a low level of agreement was accounted for sometimes. These results are shown in Figure 4.64.

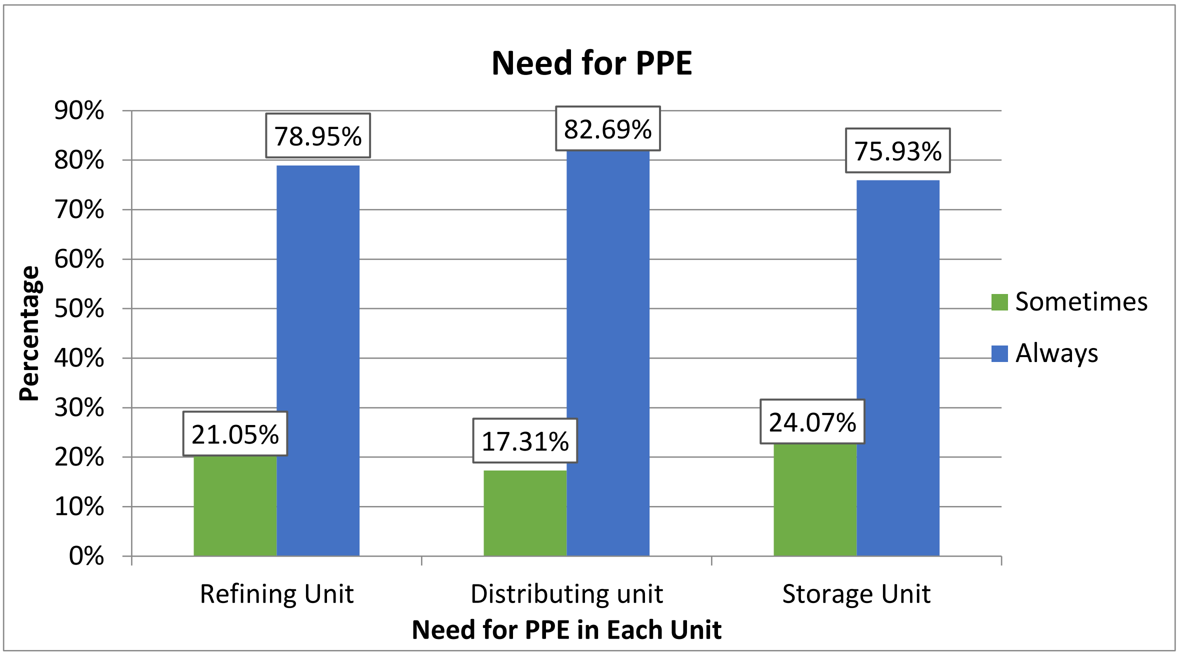

Figure 4.64: Cross-case Analysis for the Need of Personal Protective Equipment in Job

Sixth, respondents were asked about their work location whether it is indoor or outdoor and this information is presented in Figure 4.65. The highest responses in the three units were found in indoor location while a small portion of responses within the three units pointed that they deal with outdoor work location.

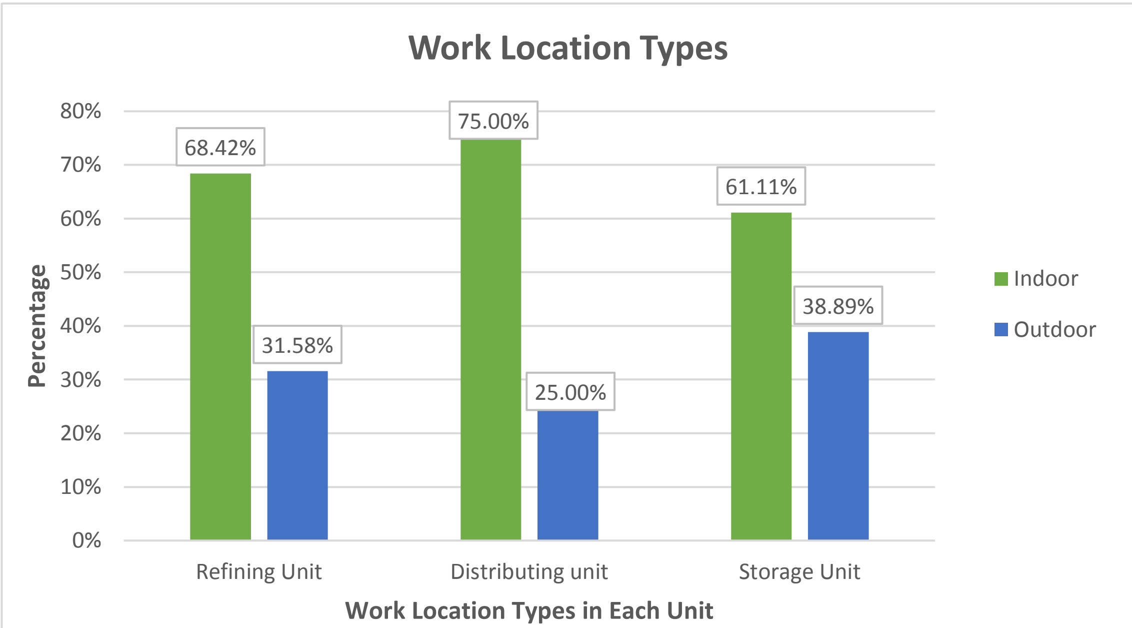

Figure 4.65: Cross-case Analysis for Work Location Types

Seventh, respondents were asked about the noise level in their workplace. A significant portion constituted the vast majority of responses from the three units with more than (75%) agreed that their workplaces have a high level of noise. Whilst the remaining percentages are for medium and low noise level as shown in Figure 4.66. According to Lavanya, Rajesh and Sunil (2014), workers in O&G industry are exposed to chemicals produced and used in O&G industry that may suffer occupational accidents and they are exposed to hazardous noise levels that may suffer noise-induced hearing loss (NIHL). In order to effectively control exposure to noise hazards in O&G industry, they stressed the importance of adapting several noise control measures like noise-badge (tagged) to personally evaluate the noise exposure and personal hearing protective devices.

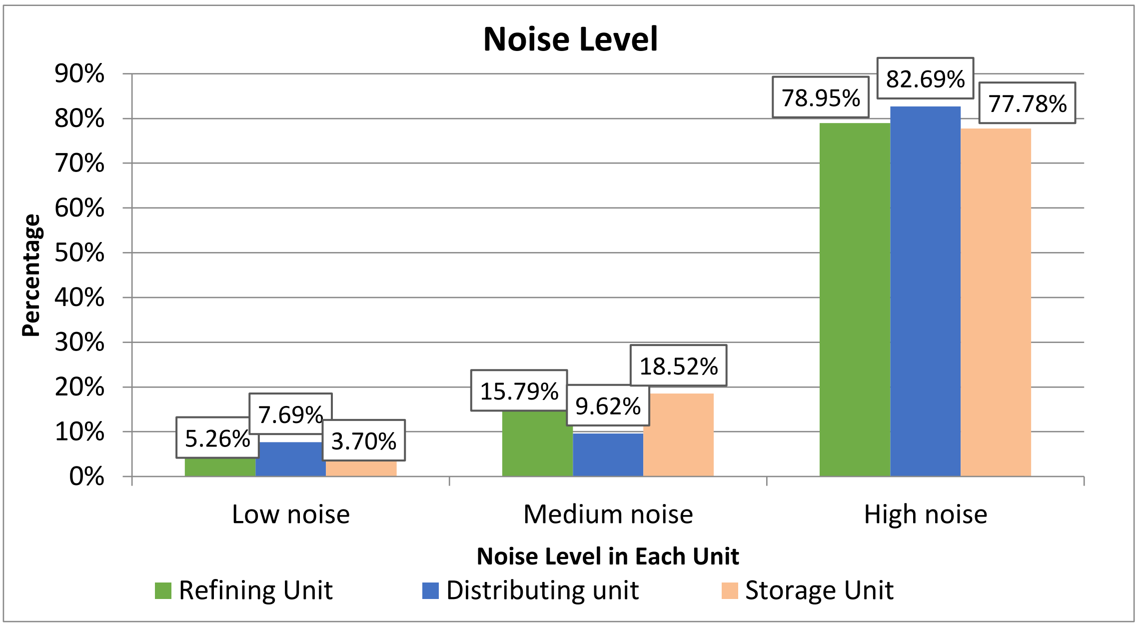

Figure 4.66: Cross-case Analysis for Noise Level

Last but not least, respondents were asked about the clarity of the communication language among the employees. Responses are presented in Figure 4.67. The results shows that around a half of responses from each units described the clarity of communication language by bad. Then, different lower results were obtained for medium and low clarity. Regarding medium clarity of communication language, the storage unit has the highest percentage. While regarding a good clarity of communication language, the refining unit has the highest percentage.

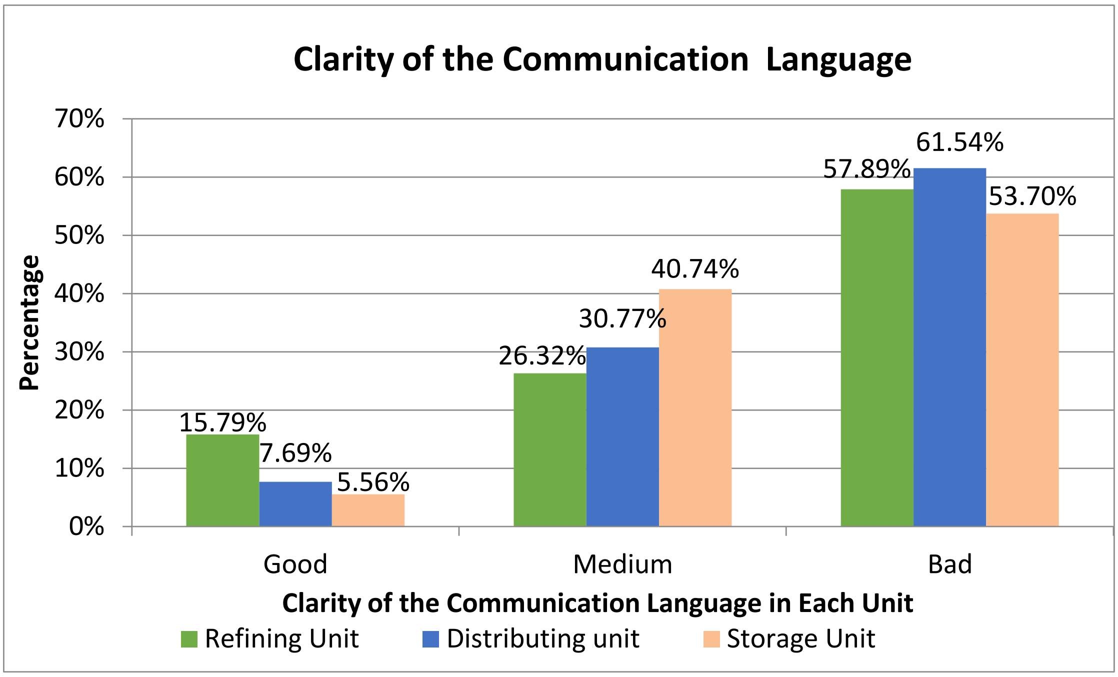

Figure 4.67: Cross-case Analysis for Clarity of the Communication Language

4.5.2.3 Opinions on Workplace

The third section provides the judgments and opinions of the operational level of all the three units against *Safety_regulation, Safety_implementation, Top_management, Safety_training, Safety_leadership, Communication and Accidents_reporting_system* constructs. Results are shown in Table 4.26.

Table 4.26: Cross-case Analysis for Questionnaire Surveys' Constructs

Questionnaire Surveys' Constructs (Challenges Related to Human Error Accidents)	Cases		
	Refining Unit	Distributing Unit	Storage Unit
Safety regulation		✓	✓
Safety implementation	✓	✓	✓
Top management			
Safety training	✓	✓	✓
Safety leadership	✓		✓
Communication	✓	✓	
Accidents reporting system	✓	✓	✓

Based on the results in Table 4.26 of the operational level, a high level of consensus revealed between the refining, distributing and storage units that highlighted safety implementation, safety training and accidents reporting system as challenges to human error accidents in the O&G industry in Bahrain. Additionally, the refining and distributing units agreed that communication is also a challenge to human error accidents while the distributing and storage units agreed that safety regulation is a challenge to human error accidents. Further, the refining and storage units agreed that safety leadership is a challenge to human error accidents. Overall, there are six challenges related to human error accidents based on the point of view of the operational level of the three units. These challenges are safety training, safety implementation, accidents reporting system, safety regulation, safety leadership and communication.

However, some significant correlations were identified between the challenges of each unit. These correlations were computed using the Spearman's rank order correlation coefficient in SPSS. All these correlations were positive ranging between low correlations to very high correlations. A summary of these correlations in each unit is expressed in Table 4.27.

Table 4.27: Cross-case Analysis for Spearman's Rank Order Correlation Coefficient

Unit	N	Number of correlations	Range of correlations
Refining Unit	57	10	+0.587 to +0.915
Distributing Unit	52	10	+0.441 to +0.785
Storage Unit	54	4	+0.306 to +0.835

Apart from that, as the scores of these challenges in the three units were not normally distributed, a nonparametric test (Mann-Whitney U test) was used to compare differences between fixed schedule employees and shift employees and between indoor employees and outdoor employees in their agreement on each challenge in their unit. First, regarding the agreements on the safety regulation as a challenge related to human error accidents, results of the Mann-Whitney U test revealed that shift schedule employees had significantly greater results than for fixed schedule employees in the refining and distributing units while there was no difference between these two groups in the storage unit. Moreover, results showed that outdoor employees had significantly greater results than for indoor employees in the refining and distributing units while the opposite result was found in the storage unit.

Second, regarding the agreements on the safety training as a challenge related to human error accidents, results of the Mann-Whitney U test revealed that shift schedule employees had significantly greater results than for fixed schedule employees in the three units. Likewise, results showed that outdoor employees had significantly greater results than for indoor employees in the three units.

Third, regarding the agreements on the accidents reporting system as a challenge related to human error accidents, results of the Mann-Whitney U test revealed that shift schedule employees had significantly greater results than for fixed schedule employees in the refining and distributing units while there was no difference between these two groups in the storage unit. Likewise, results showed that outdoor employees had significantly greater results than for indoor employees in the refining and distributing units while there was no difference between these two groups in the storage unit.

At this point, the cross-case analysis for the qualitative data and quantitative data are illustrated. The next section describes the document analysis.

4.5.3 Results from Cross-case Analysis

Results from the cross-case analysis for the qualitative data show that all units confirmed that OHS framework needs more developments aligning with the rapid changes in the O&G industry. In this regard, results from the refining unit reveal that this framework should be coordinated and managed by a special coordinator or authority and should focus on providing certain legislations and regulations for the O&G industry based on the industry requirements and specifications. On the other hand, results from the cross-case analysis for the qualitative data in the storage unit show that the existing OHS framework in Bahrain complies with some international regulatory requirements while results from the cross-case analysis for the quantitative data in this unit reveal the opposite of that. This conflict in points of views may be due to the different scales taken by the managerial level and the operational level in evaluating the current OHS framework.

Additionally, results from the cross-case analysis for the qualitative data and quantitative data confirm that the O&G industry in Bahrain has a high level of risk and there are different types of risks exist within workplaces. However, these results reveal that each workplace or unit differs in the types and level of risk based on various factors like nature of operations, size of units, types of materials and equipment, the nature of work (work schedule, weekly working hours and work location) and level of pressure, heat and noise. Moreover, results from the cross-case analysis for the qualitative data indicate that there are different types of preventive measures, techniques and controls that are adapted in each united to reduce and prevent these risks. On top of that, results from the cross-case analysis for the quantitative data highlight that working in all units in the O&G industry in Bahrain always requires putting on the PPE in most situations.

Furthermore, results from the cross-case analysis for the qualitative data from only the distributing unit present that safety in Company A is a critical record while from the storage unit present that there is a good achievement in safety in Company A. However, results from the cross-case analysis for the quantitative data from the refining and distributing units show that safety implementation is a challenge related to human error accidents in the O&G industry in Bahrain. This contradiction in points of views puts a question mark on safety and safety implementation that should be addressed by the industry.

In addition, results from the cross-case analysis for the qualitative data confirm that human error is a main cause of most of accidents in the O&G industry in Bahrain and it can be defined as a negative act or action that leads to harm to workers and losses in workplace and environment. Further, results from the refining unit highlight that human error can be a form of low safety behaviour. Moreover, these results show that there are different examples of human error accidents like loss of focus, lack of judgment, shortcut and careless while the most common examples in the three units are overconfidence and ignoring the importance of wearing PPE.

There are different challenges related to human error accidents in the O&G industry in Bahrain. Results from the cross-case analysis for the qualitative data highlight eight challenges related to human error accidents which are safety bahaviour, safety training, accidents reporting system, role of safety leadership, safety culture, safety implementation, communication and role of top management. Whereas, results from the cross-case analysis for the quantitative data highlight six challenges related to human error accidents which are safety training, safety implementation, accidents reporting system, safety regulation, safety leadership and communication. Based on that, results from the analysis of the two sets of data highlight in total nine challenges in which they agree on five challenges which are safety training, safety implementation, accidents reporting system, communication and safety leadership and differ in four challenges which are safety bahaviour, safety culture, role of top management and safety regulation. Accordingly, consideration should be given to these challenges in order to reduce the probability of human error accidents in the O&G industry in Bahrain.

In this regard, results from the cross-case analysis for the qualitative data presents an array of recommendations and suggestions that are required to overcome these challenges and reduce human error accidents. Some examples of these recommendations are like developing the appropriate safety training, considering the capabilities, abilities, vulnerabilities of workers in the design of tasks and workplace, sharing recommendations, corrective actions, safety information and feedbacks in the accidents reporting system, promoting and fostering a positive safety culture and adapting various risk controls and measures, regular safety audits and new safety technologies in order to reduce and control risks and hazards. Furthermore, these results spotlight on the key role of government support in order to overcome these issues by providing a powerful governmental regulatory, building a robust OHS framework and building effective relationships international partnerships and contractors. Apart from that, results from the cross-case analysis for the qualitative data highlight two types of best safety practices that are adapted in the O&G industry in Bahrain which are Operational Excellence and Solomon Fuels Study. Finally, these results from the cross-case analysis for the qualitative data reveal an agreement between the three units on the need for a safety strategy in the O&G industry in Bahrain. This strategy should be built on the current requirement of the industry, international regulatory and global market.

4.6 Document Analysis

Document analysis is an analysis to present data by systemically reviewing the non-technical documents in which the identified data will be combined with further methods as a source of triangulation (Bowen, 2009). This analysis is adapted to identify the current OHS legislation, regulations and implementation in O&G industry in Bahrain (second objective of the current research) and to evaluate critically the challenges related to human errors specific accidents in O&G industry in Bahrain (third objective of the current research). To conduct this analysis appropriately, there should be an accurate data selection rather than data collection. In this accordance, Coffey (2014) indicated that the researcher should be attentive to the content of documents, the structure of these documents, and the functions to which they are put. Based on that, credibility, authenticity and representativeness were considered in choosing the documents. The chosen documents are tabulated in Table 4.28 and the adapted procedure for reviewing these documents is presented in Figure 4.68.

Table 4.28: Description of the Selected Documents

Document No.	Document Title	Author/ Authority
Document 1	Occupational Health and Safety Report	Bahrain News Agency (2013)
Document 2	Economic Yearbook 2013	Bahrain Economic Development Board (2013)
Document 3	Annual Report 2013	Bahrain Tatweer Petroleum Company
Document 4	Bahrain Economic Quarterly 2014	Bahrain Economic Development Board (2014)
Document 5	Bahrain Economic Quarterly March 2016	Bahrain Economic Development Board (2016)
Document 6	Annual Report 2017	Bahrain Economic Development Board (2017)
Document 7	Bahrain Economic Quarterly 2018	Bahrain Economic Development Board (2018)
Document 8	Annual Report 2018	Bahrain Economic Development Board (2018)

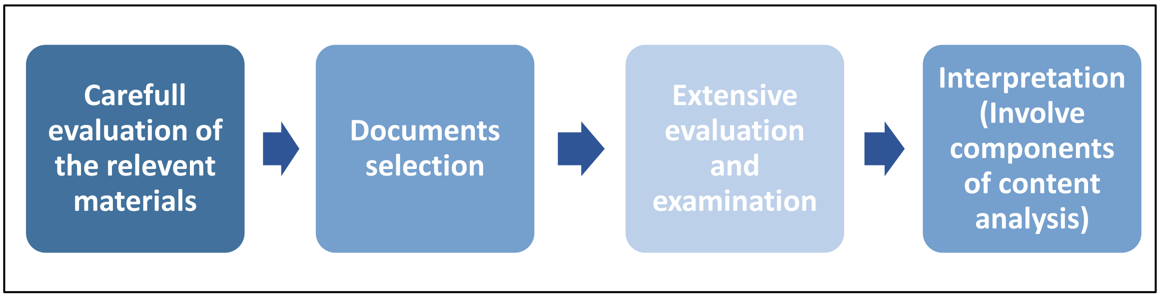

Figure 4.68: Procedure for Reviewing Documents

Both print and online documents like legislation, reports, and databases regarding O&G industry in Bahrain, occupational accidents and human error accidents were carefully evaluated and the most credible and relevant materials were selected for the current research through a screening process. Thereafter, a thorough examination of the chosen material was carried out and deduced to yield relevant answers. This analysis combined several components of the content analysis to elicit results.

4.7 Limitations

This section discusses the limitations of the results regarding their validity and representativeness. Time, vagueness and transferability are the main three limitations in this research. In term of time limitation, time was a major constraint particularly during the data collecting phase within O&G industry in Bahrain and in each unit due to the privacy policy of the company, confidentiality and the work pressure. Thus, this may have affected some parts of the analysis presented in this chapter. For instance, the numbers of interviews were limited due to time constrain which was nearly few weeks. However, as the data collection phase was during the summer season and particularly during Ramadan which is a special time for Muslim for fasting, thereby; subjective feelings of fatigue and malaise were clear on a portion of interviewees. On the other hand, in term of vagueness, several answers were vague and not easily to analyse. As a mean of illustration, some interviewees were able to reply on particular schemes of questions but they moved one-step closer to skip or end certain questions or matters. Vague answers might be a result of vague questions in spite of the precise steps that were taken in Chapter 4 to avoid it. It is important to note that even if these two limitations indicate that some responses may not reflect or express the overall real setting of O&G industry in Bahrain, the capability of the employed research methodology, strategy and methods in the current research addresses that. Finally, transferability is the extent to which the study has made it possible for the reader to use and adapt the findings in the situations investigated to another similar situation (Bloomberg & Volpe, 2008; Lincoln & Guba, 1985). Thus, to accomplish an effective level of that requires a systematic reporting for all evidences in all research phases in order to convince readers. Therefore, this needs a precisely work. time and effort. This presented as a limitation due the complicated requirement of this research and the case study as well that should be applied to the three units. In this regard, the investigator in this research tried to provide most valuable descriptive data to make transferability possible. For example, the detailed discussion on the number, demographic characteristics and profile of the participants of the interviews and questionnaire surveys, the procedures of selecting the sample, the description of the adapted methods and techniques for collecting and analysing data. Moreover, detailed and in-depth explanations of the results of the three units were provided with the appropriate evidences like the quotes from the interviewees of each unit.

4.8 Chapter Summary

This chapter presented the analysis of the qualitative and quantitative data. A case study analysis is conducted for the semi-structured interviews of each unit separately. Then, a case study analysis is conducted for the questionnaire surveys of each unit separately. All results are presented. After that, the results of the cross-case analysis for the qualitative data and quantitative data are presented across the refining, distributing and storage units. All findings and outcomes of the cross-case analysis are presented and justified. Finally, the last analysis that is the document analysis is presented. The next chapter presents the findings of this research in an effective way by developing an action plan for enhancing the industrial safety strategy. All the identified results are important building blocks for the next chapter.

CHAPTER 5: DISCUSSION

5.1 Introduction

In this thesis, five main objectives were stated in order to achieve the aim of enhancing the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan. The first four objectives were discussed in the previous chapters. The first objective, to define human errors and human factors within the context of accidents in general, was introduced in Chapter 1 and comprehensively discussed in the literature review in Chapter 2. The second objective, to identify the current OHS legislation, regulations and implementation in O&G industry in Bahrain, was addressed in Chapters 2 and in Chapter 4 (in term of primary research). The third objective, to critically evaluate the challenges related to human errors specific accidents in O&G industry in Bahrain, was considered in Chapter 4 (in term of primary research). The fourth objective was achieved through the literature review of Chapter 2 and Chapter 4 (in term of primary research).

The results of all these objectives draw a deep understanding regarding the context of human error accidents in O&G industry in Bahrain by focusing on the refining, distributing and storage units. This understanding is built from the opinions and judgments of the managerial level and the operational level of this industry by highlighting the definition and nature of these accidents and the related challenges, the current OHS framework and the adapted best safety practices. Accordingly, the fifth objective is prepared. The understanding and main findings assist in developing an action plan that reduces the potential of human error accidents in O&G industry in Bahrain. The cross-case analysis in section 4.5 in Chapter 4 tends to identify similarities and outliers across cases. The empirical findings have been presented in Chapter 4 in the case study analysis for each case and in the cross-case analysis. The findings also replicate some concepts that were defined in the literature review (see Chapter 2). For instance, the results affirm all that accidents reporting system is one of the main challenges.

The presentation of these empirical research findings is provided in this chapter. These empirical findings are organised, structured and conceptualised to enhance the industrial safety strategy. Therefore, it is important before discussing this strategy to present first the key empirical results of this research. This presentation is in the next section followed by the essence of this strategy. Then, a draft overview of the developed industrial safety strategy based on the empirical results in Chapter 4 has been sketched based on the context of the O&G industry in Bahrain. In light of this draft overview, this chapter provides an in-depth description of the proposed industrial safety strategy for the O&G industry in Bahrain by concerning on several elements like the vision, mission, outcomes, users, performance indicators and results and key action areas. Then, the refining phase and the amended topics are also included. This refining process was undertaken to ensure the validity of this strategy using a number of experts in O&G industry in Bahrain. Finally, the final conceptual view of the industrial safety strategy is also presented in this chapter.

5.2 Empirical Findings and Linkage

The aim of this section is to present the main empirical results in this study that are used to enhance the industrial safety strategy in the next sections. Table 5.1 presents these findings in relation to each objective of this research.

Table 5.1: Empirical Findings of the Present Study in Relation to Each Objective

Objective	Identified Results	Cross-link	Explanation
Objective 1: To define human errors and human factors within the context of accidents in general.	It is a negative act or action that leads to harm to workers and losses in workplace and environment.	Case study analysis and Cross-analysis for the qualitative data.	Human error is the cause of most of accidents in O&G industry in Bahrain. Human errors accidents are common and they can be a form of low safety behaviour**.** Examples of human error accidents are overconfidence, ignoring the importance of wearing PPE, loss of focus, lack of judgment, shortcut and carelessness.
Objective 2: To identify the current Occupational Health and Safety legislation, regulations and implementation in the Oil and Gas industry in Bahrain.	The current OHS framework in O&G industry in Bahrain complies with national and international regulations and standards, and has an acceptable progress. Risk in O&G industry in Bahrain is everywhere but the level of risk	Case study analysis, Cross-analysis for the qualitative data and document analysis.	Although the current OHS framework has an acceptable progress, reducing the probability of exposure to hazards and risks and the probability of human errors are important concerns. In this regard, OHS framework needs a coordinator, more improvement in

	is based on the nature of each workplace .In general, the O&G industry has a high level of hazards.		comparison with the rapid changes and specific regulations for O&G industry. Different preventive measures, techniques and controls have been adapted to reduce and prevent risk in workplaces. Based on the high level of risk in this industry, PPE is required always.
Objective 3: To critically evaluate the challenges related to human errors specific accidents in O&G industry in Bahrain.	There are different challenges related to human error accidents in O&G industry in Bahrain. These challenges are safety training, accidents reporting system, safety behaviour, safety implementation, safety leadership, the role of top management, safety culture, communication and OHS regulations.	Case study analysis, Cross-case analysis for the qualitative data, Cross-case analysis for the quantitative data and document analysis.	Based on the results, several recommendations and suggestions are identified to reduce human error accidents. Results indicated that the design of tasks and workplace should consider capabilities, abilities, vulnerabilities and diversity of workers. In addition, identifying, reducing and controlling risks and hazards are important taking advantages from various risk controls and measures,

			regular safety audits and observations and new technologies. Beside, developing workers' competencies and providing the appropriate safety training are also critical. As well as, communication and collaboration with workers, suppliers and other stakeholders play a key role in this case. However, accidents reporting system should maintain the accreditation and share recommendations, corrective actions, safety information and feedbacks. Promoting and fostering a positive safety culture contribute positively to the reduction of human error accidents. Nevertheless, involving employees in safety matters and increasing their safety awareness are also important. Further, focusing on

			safety research and development is a priority. On top of that, government support is the heart of all improvements in the industry by providing a powerful governmental regulatory and building a robust OHS framework and regulations based on the industry specific. Relations with partnerships and contractors should be included in this framework as well. On top of that, safety compliance and safety best practices are contributes points. More explanations of these points are provided in the developed action plan.
Objective 4: To explore best safety practices from other O&G industries in developed and industrial countries.	O&G industry in Bahrain adapts two common international best safety practices which are Operational Excellence and Solomon Fuels Study.	Case study analysis and Cross-case analysis for the qualitative data.	Although O&G industry in Bahrain adapts these best practices, it should continuously search for these ready-made solutions. A professional team should be established to concern about this precisely.

Objective 5: To refine and validate the recommendations of the industrial safety strategy for the O&G industry in Bahrain	Currently, O&G industry needs an industrial safety strategy that should be developed by the industry and government cooperatively.	Case study analysis, Cross-case analysis for the qualitative data and Cross-case analysis for the quantitative data.	Safety strategy is a critical need to O&G industry in Bahrain especially after the recent largest oil well discovery. Nevertheless, the distributing unit agreed that O&G industry does not just need this strategy but instead it needs also an accurate and effective implementation for it by all interested levels and parties in the industry. It provides an aspirational and positive destination for O&G in Bahrain by directing the attention on matters that could make differences and on reframing the current challenges.

5.3 Proposed Industrial Safety Strategy

As discussed previously, the O&G industry in Bahrain will continue to change due to dynamic alterations in the market, economy, technology and OHS regulations internally and internationally. Although these changes will bring new opportunities for a safe workplace, new risks will be inherited to the workplaces. Therefore, O&G industry in Bahrain should constantly ensure first that all workers have the right to work in a healthy and safe environment and secondly that all workplaces are well designed, healthy and safe. Considering these two things assists in achieving excellence in OHS performance among regional and international competitors. This means that focusing on investing in both hard infrastructure which is the physical and natural capital and in soft infrastructure which is the human capital-building in this industry will bring successful benefits and help the industry in meeting the existing and future priorities and requirements. This point is a vital strategic priority for enhancing the industrial safety strategy.

Building an action plan for enhancing the industrial safety strategy by considering human error attributed accident is the centrepiece of this research. In social science research, the term framework is differently defined by various scholars. According to Ngulube, Mathipa & Gumbo (2015), a research framework is a tool for the researchers to understand and deduce empirical findings. While, Patrick (2018) referred research framework as a logical representation for particular variables, factors, concepts, or relationships based on a scientific study. Based on that, the empirical findings from the present study are logically arranged to facilitate the understanding and interpretation of the investigated problem.

Building an action plan for enhancing the industrial safety strategy for O&G industry is a powerful tool to address the current challenges, resolve specific issues and guide the safety performance of the entire industry. In other words, it is a long-term plan that exhibits the industry's numerous pros and inhibits its cons. A well-developed action plan for the industrial safety strategy assists in building an integrated solution to increase the safe actions and decrease the probability of human error accidents in the workplace. OHS principle is a core of this strategy by ensuring that nobody will be seriously harmed while doing the daily tasks. A well-designed strategy for this research must be anchored to national Bahraini laws and regulations and it should not overlooked or downplayed the environmental and ecological resilience. Further, this industrial safety strategy must be considered as an extensive commitment to the O&G industry management.

5.3.1 The Essence of an Industrial Safety Strategy

This strategy provides a living reference for O&G industry's structure and behaviour. This strategy provides a sense of purpose and direction in the workplace. Further, it provides an aspirational and positive destination for O&G industry in Bahrain by directing the attention of the industry on matters that will make a difference and on reframing the current challenges. This means that this strategy assists in improving the future path and OHS performance of the industry by considering the fact-based picture from the analysed results of Chapter 4. The fact-based picture is represented by the current resources, requirements and challenges in O&G industry that were identified mainly from Chapter 4 or even the other chapters. Having this fact-based picture is fundamental because building an effective action plan for enhancing the industrial safety strategy depends on the current situation of O&G industry. Thus, this industrial safety strategy provides a realistic appraisal of safety across the whole industry. Additionally, this strategy allows the management to design effective safety strategies and policies to the workplace. As this strategy is about a safety culture in which everyone can share and from which everyone can benefit; thereby, implementing this strategy in O&G industry in Bahrain creates and stimulates a positive safety culture throughout the industry. The industrial safety strategy is about changing attitudes, involving people, raising standards (Heseltine, 2017). O&G industry, workers, contractors, communities and environment will all benefit regardless of their occupation or how they are engaged in this strategy.

5.4 Overview of the Proposed Industrial Safety Strategy

This research tends to enhance the industrial safety strategy in O&G industry in Bahrain by considering human attributed accidents. Therefore, this section provides an overview regarding this strategy. It is built on the analysed data of the semi-structure interviews and questionnaire surveys in case study analysis, cross-case analysis and document analysis. It also strongly considers the nine challenges to human error accidents and the suggested recommendations. This strategy will assist in tackling the current challenges effectively, addressing the cultural, operating and regulatory current requirement of this industry in Bahrain and reflecting the reality of current environment. The proposed industrial safety strategy is comprised of several important elements as vision, mission, outcomes and focus areas.

5.4.1 Vision

The vision of the proposed strategy is to deliver healthy, safe and profitable workplace.

5.4.2 Mission

The aim of this strategy is that every day all worker goes home safe and healthy.

5.4.3 Outcomes

This strategy has been built to undertake vital activities to accomplish several improvements in the overall OHS performance in O&G industry in Bahrain. The vision of this strategy is reached by setting out four outcomes that will be achieved by the next coming five years. These outcomes are:

1. Reducing human error accidents.
2. Reducing exposure to hazards and risks.
3. Improving workplace safety and OHS framework.
4. Improving human resource management

It is important to note that achieving the vision and the outcomes required a concerted effort by all individuals who have interest in O&G industry in Bahrain and can either affect or be affected by this strategy.

5.4.4 Users

This strategy is particularly aimed at Bahraini government, O&G industry, OHS regulators, partnerships, practitioners, managers, policy makers and other parties that have an influence at any level over O&G industry in Bahrain. All these key stakeholders and interested parties need to work collaboratively and have to perform activities that lead strongly to achieve the proposed vision and outcomes. Two significant users-related factors contribute to the effectiveness of this strategy. The first one is expanding and strengthening the extent of involvement of all these parties during the implementation phase. The second one is OHS improvement requires a continuous cooperation and collaboration among all stakeholders in this industry.

5.4.5 Performance Indicators and Results

Several key performance indicators have been designed to measure the success of this industrial safety strategy. The number of human error accidents and the accidents rate are two significant indicators to monitor progress of this strategy. Beside that, this strategy has been designed to improve the everyday lives of workers in O&G industry in Bahrain in order to reach positive outcomes. Several performance improvement will be achieved during the implementation of this strategy like:

1. A reduction in human error accidents.
2. An increase in the number of workers who have the right training programmes.
3. An increase in the recorded safety conversations and communications.
4. An increase in safety awareness and commitment.
5. An increase in sharing and exchanging safety information.
6. An increase in the number of attendance of the induction training refresh each year.

5.4.6 Key Action Areas

In order to achieve the proposed industrial safety strategy, sustaining consistent attentions and efforts on the identified key action areas is utmost important. Nine action areas have been designed at the heart of this strategy. These action areas help in meeting the predefined outcomes. These action areas are accidents reporting system, safety leadership and safety culture, safety training and competence, communication and engagement, safety authority, OHS framework and safety compliance, workplace design and risk management techniques, technology and research and development. These action areas are discussed in the following sub-sections.

5.4.6.1 Workplace Design and Risk Monitoring and controls

Creating a healthy and safe workplace in O&G industry is essential to ensure that all workplaces are well-designed and equipped to work safely, empowered to take safe decisions and well-prepared with the required information to make them. In this regards, the HSA (2011) in UK had identified a strategic objective of a safe workplace 'identify the major hazards associated with your work activities and to ensure that appropriate controls are in place before work commences'. Having a good design of workplace means the structures, materials, equipment, technology, processes, systems and the overall interactions between these and other components are considered during the workplace design phase. This also means that the design of tasks and workplace procedures are aligned with capabilities, abilities, vulnerabilities and diversity of workers.

This can be achieved by adapting several techniques and assessments that concern practically on preventing or reducing exposure to hazards and different types of critical and ongoing risks. These controls and measures assist managers in identifying hazards and understanding how to manage associated OHS risks and hazards, judge on the effectiveness of the controls and communicate with workers. These techniques and measures assist in ensuring that risk is as low as reasonably practicable in this high-risk environment. Prevention activities and controls that are designed to prevent accidents also should be directed to effectively control hazards and risks in the workplace. This requires improving and promoting the professional practices of risk management. Beside that, O&G industry should ensure that risk controls are robust and error tolerant and should focus on the presence of effective controls and proactive measures. Apart from that, it is important also to undertake regular safety tours, audits and observations in order to guarantee the effectiveness of the workplace design and these measures. Another important point is productive equipment and machinery. These components are complex and expensive to build; therefore, these components should be able to be exposed to harsh environmental or working conditions and need regular maintenance to replace or repair its parts (PwC, 2017).

5.4.6.2 Safety Training, Capabilities and Competencies

No industrial safety strategy can be credible if it does not concern on workers and safety skills and knowledge. Workers are intrinsic to improving and promoting OHS outcomes and risks management. Therefore, it is essential to support and develop their competence continuously and particularly in the context of any changes in OHS regulations (Spillane & Oyedele, 2013). Accordingly, O&G industry should ensure that all workers have the appropriate safety training, capability and competency to fulfil their role safely and efficiently and to make informed decisions. Safety training is an integral component of a long-term accidents prevention and mitigation strategy. As some previous failures in O&G industry mean that workers were likely to under-invest, O&G industry should invest in safety training as it strongly promotes more safety skills and knowledge which in turn will increase the overall OHS performance. Evidence confirms that higher skilled workers are more productive and they can increase the productivity of others and positively affect innovation in the workplace (Duranton & Puga, 2014). O&G industry should provide enough training courses for workers to combat vulnerability, build resilience and expand opportunities for learning in the workplace. Apart from that, post-testing and evaluating the effectiveness of training courses or programemes in solving the unsafe behaviours and situations are important factors to assess how much has been learned and to obtain feedback. A refresher training should also take place. Safety training programmes also should be updated regularly to enable workers to address adequately old and new risks, hazards and circumstances.

On the other hand, capability is considered as a fundamental and powerful driver for performance over time (Ahmed, 2017). Thus, safety capabilities are the factors that assess how are workers good at performing the critical tasks in the workplace. Identifying and measuring safety capabilities in a workplace is important because it determines how effectively a workplace builds, develops and retains resources. Although it is hard to achieve that in a risky workplace, attentions of safety specialists and professionals must be directed to understand and manage these capabilities. Additionally, this industry should continually ensure the improvement of safety standards and the quality of safety training and capabilities. Further, the concern should be directed to build consistently high levels of professional safety competencies across all areas of O&G industry in Bahrain. To build and promote that, the workers and safety leaderships should have the resources (qualifications, experience, and qualities) they need to do the work safely and efficiently, believe that this industry is committed to keeping them healthy and safe, and know clearly their rights and responsibilities in the workplace.

5.4.6.3 Communication and Engagement

O&G industry cannot achieve the vision of this industry without the help of workers and others. Communication and collaboration with workers, suppliers and stakeholders have an integral role in enhancing this strategy by using various communication measures and protocols. O&G industry should develop an internal network, build confident and assurance to it, and engage safety leaders with all workers regularly. Furthermore, effective and strong communications and interactions among all employees facilitate and simplify many critical concerns in the industry. Effective means of communication between the workers include verbal, visual and written methods at all times (Spillane & Oyedele, 2013). These links which are created between all workers help in sharing different knowledge and expertise that are required for daily or rare cases. Strong communication provides all the required information about hazards, risks assessment results and preventive measures and ensures that issues are addressed with suitable actions. Strong communication also opens doors for building an open culture where all workers feel free to report matters and convey ideas without any restrictions or fear. In this case, a strong communication permits and encourages workers to talk and introduce their ideas freely. Apart from all internal communications concerns, O&G industry should concern on external communication because effective interrelationships and partnerships are essential components of success (Heseltine, 2017). Therefore, this industry should build new partnerships regionally and internationally to consult, communicate and share safety information, experience and best practices. It should also strengthen the strategic relationships with them and engage with key industry partners on OHS initiatives.

5.4.6.4 Accidents Reporting System

The importance of accidents reporting system to the success of the proposed strategy cannot be overstated. Addressing the weaknesses and deficits in the accidents reporting system and ensuring better utilisation of this system and others must be core to this new strategy. This system should provide clear, concise and consistent OHS information and standards for all workers. O&G industry should maintain the accreditation of this system and continue to improve it. Further, accidents reporting system should include certain information about the date, place and time of the accident, names and occupations of persons harmed, a brief explanation of the accidents , a statement of the sequence of events that have been led up to the accident and documentation of any unsafe act, condition or procedure that had contributed to the accident. Moreover, recommendations and corrective actions and procedures that can prevent similar accidents should be spelled out, undertaken and followed-up. However, lessons learned should be shared and disseminated to all workers in this industry. It is essential that this system share safety information, feedbacks, corrective actions and solutions to mitigate risks. These information and records help O&G industry in the present time and future in term of decreasing the probability of repeating the same accident if and only if applicable, suitable and consistent actions have been undertaken first.

Additionally, paying a great attention to retain this information is a primary requirement to introduce and incorporate safe work practices and to improve the current safety procedures and processes in the workplace.

5.4.6.5 Safety Leadership and Safety Culture

The core role of safety leadership is promoting and fostering a positive safety culture in O&G industry. This done by demonstrating a commitment to different aspects like risks management, safety consultation, clear bi-directional communications, compliance with safety standards and procedures, organisational learning and appropriate training. Elsler, Flintrop, Kaluza, Hauke, Starren, Drupsteen & Bell (2012) indicated that the United States OSHA reported that the power of safety leadership plays a key part in addressing safety issues. Safety leadership is the one who is responsible not just for initiating safety actions across the workplace but also ensuring OHS standards are consistently applied in the daily tasks and activities and improving long-term profits. This means that safety leadership in O&G industry should have the answers for why the workplace's safety performance is following its current path, where current OHS framework will lead, and how the future can be enhanced. O&G industry should establish a team of informal safety leaders who can investigate, audit and demonstrate safe work. Safety leadership is a powerful driver of change in the workplace through their management, education and OHS practices. In other words, as safety leadership behaviours and attitudes are observed by and can influence workers, setting a good example in the eyes of workers in the workplace is a strategic contributor to this industry.

Thus, improving safety culture is strongly affected by safety leadership. For instance, an effective safety leadership encourages the followers to give safety a high priority in all work processes and decisions. In fact, a positive safety culture encourages workers to work together in order to integrate OHS practices into daily work practices and communications. The main purpose of the safety culture is to modify and improve the behaviour of workers to believe in safety, think safety and be committed to safety. This will initiate the concept of self-regulation which creates a responsible worker for every action taken in order to improve safety in the workplace.

5.4.6.6 Safety Research and Development

Ensuring that there is an adequate safety research and development for the current and future safety needs and priorities is an essential strategic priority for this strategy. Proposing any safety strategy, safety policy, programs and practice or introducing any changes in O&G industry in Bahrain requires a robust evidence. As a mean of illustration, carrying out research in O&G industry is important to build a strong evidence base with a holistic view. The ongoing data development assists in developing new practical results, techniques and ventures for the industry. For instance, the industry should carry out research to look for disabling and enabling factors that lead to the required OHS outcomes. Further, safety research and development should support high quality safety discovery research and research to support O&G industry priorities. The outcomes of safety research and development should be disseminated and implemented. Nevertheless, safety research and development in this industry should be systemically coordinated and it should be supported by government. This is essential not just for O&G industry rather it is essential to the preservation of world-class academic institutions and universities in Bahrain. This support will require for example developing an application system and regulations and funding the research. Accordingly, Bahraini government should collaborate and cooperate with this industry to continually build evidence, contribute to the information exchange and undertake supporting activities through appropriate innovation and research. It also should provide funding for those professionals and academic candidates to complete a doctorate degree and apply their knowledge to this industry.

5.4.6.7 Safety Authority

Safety authority should be established as a powerful governmental regulatory that is responsible for developing OHS legislations and regulations and for coordinating the overall OHS framework in O&G industry. This authority should review, monitor and update OHS legislations, regulations, policies and practices regularly. It should also exemplify, promote, influence and deliver the highest level of OHS for workers, workplace and surrounded environment. This authority should have various tools to inforce, foster, or punish in order to change the OHS regulations, education, awareness and compliance across this industry. It should be responsive and effective in handling all that simultaneously with responding and adapting the dynamic changes in this industry. As a mean of illustration, this authority should ensure that OHS framework, procedures and processes are robust, and flexible for circumstantial agility and adaptability. Moreover, this authority should work collaboratively with all parties in this industry like companies, unions, employer associations, the community and suppliers towards the desired OHS outcomes. Additionally, this authority should have a clear plan for contractors' management to oversee and manage the contracts and partnerships in order to ensure that investments are done in line with OHS requirement and with the appropriate level of flexibility and certainty. Accordingly, it should actively work with suppliers to improve products, OHS practices and performance within all investments, procurement arrangements and contracts in this industry. By incorporating this governmental authority, relationships between all these parties should be effective, consistent, transparent, constructive and accountable.

5.4.6.8 OHS Framework and Safety Compliance

OHS framework should be introduced by government to ensure the overall desired outcomes (Heseltine, 2017). Although this strategy rightly emphasises on the essential role of the government in the formulating an effective and robust OHS framework based on O&G industry specifics, such framework should be created in cooperation with O&G industry in order to balance between the governmental strategic planning requirement and the significant specific O&G industry requirement. OHS regulations particularly protect first the public and the environment, ensure the profitability of the industry and inhibit any form of wasting resources (Ernst & Young, 2015b). There should be dedicated regulations for the O&G industry specifics for example for the exploring, drilling and processing of crude O&G and even for the construction and operation of O&G pipelines. OHS framework should be holistic in its approach and should be better connected and integrated across this industry. All components of this framework starting from OHS legislations to safety practices should be revised, supervised and updated frequently to continue improvement and towards an adequate level of international consistency and regulatory effectiveness. Safety compliance is a critical point for regulating O&G industry. Likewise, O&G industry should give consideration to safety best practices. Applying the experience of those who have passed through similar problems adequately will improve the OHS performance and outcomes, raise the quality of safety practices and explore new cooperative partnership opportunities. WHO (2012) pointed that countries are expected to take advantages tremendously from exchanging knowledge, experiences and hard-won solutions with one another.

Overall, the industry ability to implement OHS legislations and regulations, ensure compliance, set safety standards, enforce safety policy, adapt the appropriate safety best practices and coordinate safety activities is key. On the other hand, it is important that O&G industry ensures a high sense of commitment to this OHS framework and safety standards between employees within the industry. Being committed to all that builds a good background and culture which in turn affects the overall personal responsibility, enthusiasm and motivation towards noticeable degree of alignment to the standards, morals, and objectives of this industry.

5.4.6.9 Technology

Technology plays a substantial role in achieving the vision of this strategy by offering a great potential for OHS performance gains. This industrial safety strategy should embrace the dynamic technological innovations and changes and pursue to capture the advantages. These advantages are like evolving and developing OHS performance, reducing costs and creating new materials, processes, products and services. In addition, advanced technologies introduce new methods of organising procedures and processes in the workplace and enable the development of the entire industry. Further, some technologies enable more safe services to the workplace by just maintaining and upgrading the current infrastructures without any massive disruptive changes. On the other hand, O&G industry should focus on incorporating Information and Communication Technologies (ICT) that increase and strengthen the digital connectivity and wireless sensors, and provide new ways to accelerate and simplify extracting safety information and notifications. To capture the benefits of these innovations, there should be a sophisticated understanding for the effectiveness of the technology that will be adapted in term of improving the OHS performance in the industry. This understanding is an important point for this strategy to allow forward thinking on the required benefits and to steer technology in different manners that address OHS issues.

At this stage, the overview of the proposed industrial safety strategy is completed. Once this strategy and action plan have been formulated developed, it should be refined before it is practically implemented. The next section discusses the refining process of this strategy.

5.4.7 Refinig and Validation of Final Industrial Safety Strategy

This chapter addresses the last objective of the current research which is to refine and validate the recommendations of the industrial safety strategy for the O&G industry in Bahrain. The development part of this objective has been described and explained in the previous sections of this chapter but the refining part is not yet. Any strategy should be determined, refined, implemented and monitored. Therefore, this section describes the refining process of this strategy. Refining this strategy is useful to check how it is performing and making changes in O&G industry in Bahrain by identifying the strengths and weaknesses. Strengths should be exploited and exhibited while weaknesses should be confronted and inhibited. Accordingly, the proposed industrial safety strategy was sent by email to five experts who have a reliable experience in O&G industry and accidents management field to ensure that the proposed strategy is effective and consistent with current requirements and circumstances of O&G industry in Bahrain. Table 5.2 shows the profile of the selected experts for the validation process.

Table 5.2: Experts' Profile

Expert No.	Description
Expert 1	Expert manager in industrial inspection and occupational accidents
Expert 2	Head engineer in O&G operations
Expert 3	Risk analyser in industrial projects
Expert 4	Fire chief officer in petroleum company
Expert 5	Assistant professor in engineering college

Replies were received within two weeks from the experts. Based on these replies, an essential agreement was received from experts for most parts of the strategy. Some formatting and ranking changes were suggested and have been addressed. Moreover, other amendments and contributions to some sections of the strategy were received. These amendments have been considered and the proposed strategy have been modified. These amendments are explained in the following sub-sections.

5.4.7.1 Amendments to Safety Training, Capabilities and Competencies

Most of content and materials presented in this section remain the same unless one modification. This modification requires a greater level of detail to point that safety training programmes are hands-on and job-specific instructions which should be customised based on job and unit requirements. This means that each worker will get specific safety training programme based on his/her occupation, type of tasks handled and nature of unit engaged.

5.4.7.2 Amendments to Safety Research and Development

The information provided in this section is well-presented but it should include one single point. This point is that O&G industry should clearly encourage the workers to engage in the innovation path and safety research and development process. This means that O&G industry should create an appropriate incentive reward system in relation to safety research and development. This reward system should be clear to all workers.

5.4.7.3 The Final Industrial Safety Strategy

Once the amendments have been added to the proposed strategy and have been integrated with the results presented in this chapter, the final industrial safety strategy is developed completely. The presentation of this strategy is outlined with its main components in Figure 5.1 to aid those who will implement the strategy in understanding the strategy easily. The vision is the centre of this strategy. The outcomes are in the middle layer while the nine key action areas are in the last outer layer.

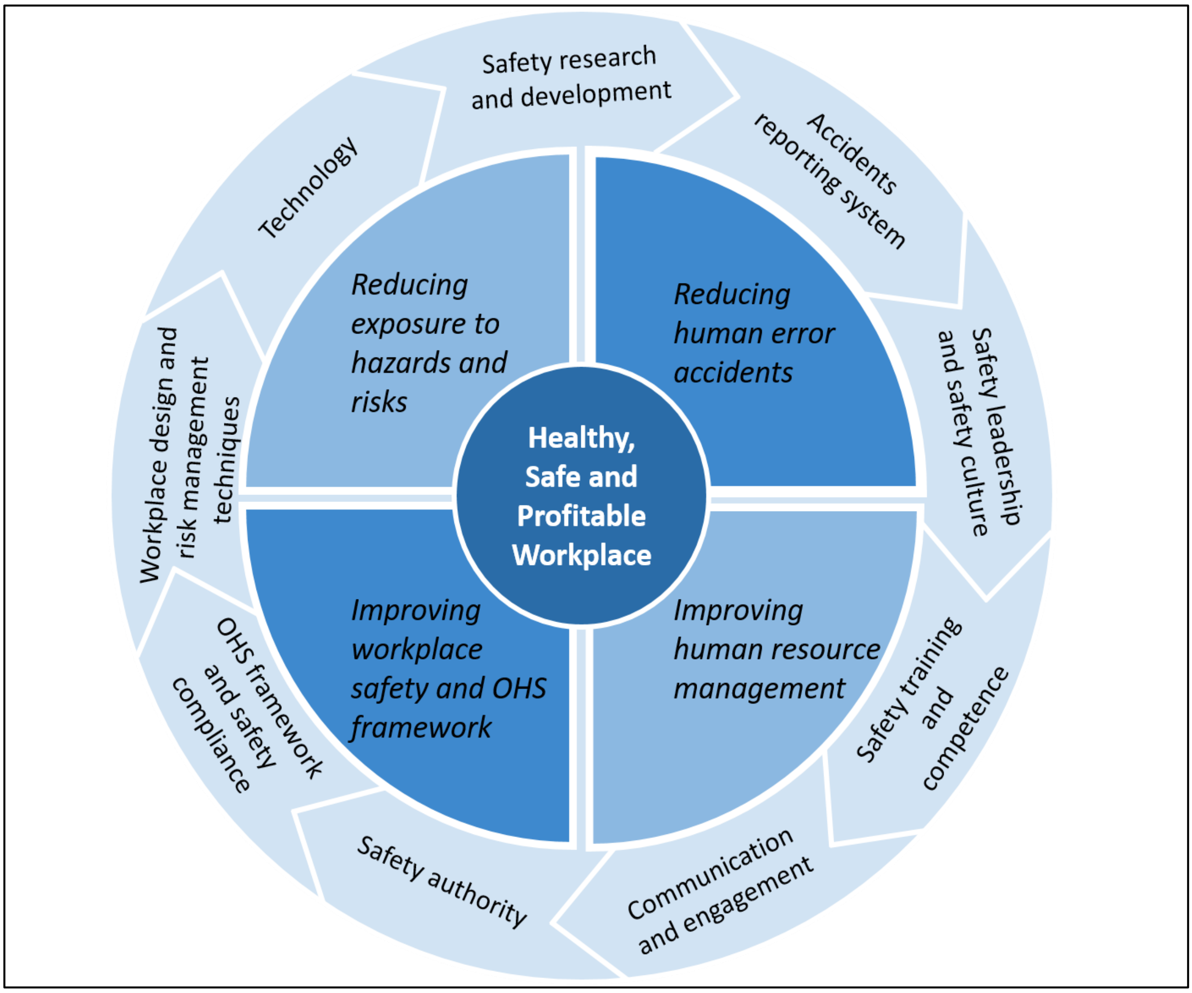

Figure 5.1: The Final Industrial Safety Strategy

5.4.8 Action Plan for the Final Industrial Safety Strategy

After refining and validating the recommendations of the industrial safety strategy for the O&G industry in Bahrain, it is important to provide an action plan to guide the user in their day-to-day work by specifing the key requirements for each action area in the strategy. A basic action-planning format for the final industrial safety strategy is shown in Table 5.3.

Table 5.3: Action Plan for the Final Industrial Safety Strategy

Action Areas	Responsibilities	Requirements
Workplace design and risk monitoring and controls	- O&G companies (Managerial level)	• Conducting regular risks and hazards assessments. • Adapting advanced techniques for O&G industry. • Restructuring the current workplaces, facilities, work process and system to reduce or eliminate hazards.
Safety training, capabilities and competencies	- Training departments - Human resources department - Contractors	• Focusing on behavioural training for O&G industry. • Updating safety programmes For O&G industry. • Developing an attractive rewarding system.
Communication and engagement	- O&G companies (Managerial & Operational levels)	• Improving workers' engagement within the O&G industry. • Maintaining interactive two ways communications within the company. • Developing a secured shared network. • Developing strategic relationships with international O&G leaders.
Accidents reporting system	- O&G companies (Managerial level) - MOL	• Designing a standardized procedure for accidents reporting system that suits with O&G industry. • Providing accessibility for the authorized parties.
Safety leadership and safety culture	- Government - NOGA	• Improving the safety behaviour for safety leaderships.

	- O&G companies (Managerial & Operational levels)	• Ensuring safety leaderships' commitment to safety goals and objectives and capabilities to contribute effectively to the OHS performance.
Safety research and development	- Government - Universities & institutions - O&G companies (Top management) - Consultation	• Emphasising on safety priorities and need for O&G industry. • A Robust government's support. • Good investments in OHS long-term plans for O&G industry.
Safety authority	- Government - O&G companies	• Considering OHS aspects in all developments. • Reviewing, monitoring and updating OHS framework regularly for O&G industry. • Transparent cooperation and collaboration between government and O&G industry.
OHS framework and safety compliance	- NOGA - O&G companies (Managerial level) - HSE department	• Ensuring regular investigations to ensure safety compliance done by O&G industry's safety expertise.
Technology	- O&G companies (Managerial level) - Service providers	• Regular maintaining and upgrading for the current systems. • Adapting advanced ICT to reduce costs.

5.5 Chapter Summary

Throughout this chapter, the importance of the results presented in Chapter 4 is evaluated. Then, the empirical findings and linkage section is discussed followed by the essence of the industrial safety strategy. Next, the main components of this strategy are discussed briefly. These components are the vision, mission, outcomes, users, performance indicators and key action areas. After that, the amendments resulted from the refining process of this strategy also have been highlighted and addressed. Finally, the last section presents the conceptual framework of the final strategy. The next chapter presents the summary of the research findings. It also describes how this thesis contributes practically and theoretically to knowledge in the O&G industry in Bahrain. Limitations and future research that can be identified from this research are also illustrated.

CHAPTER 6: CONCLUSION

6.1 Introduction

The purpose of this research is to enhance the industrial safety strategy in O&G industry in Bahrain by considering human attributed accidents. In order to achieve the core aim, five objectives were developed. These objectives address and discuss the aim comprehensively. This research is considered as one of valuable effort that contributes to O&G industry in Bahrain. For instance, the theory and empirical findings contribute to the understanding of human error accidents and its related challenges in Bahrain. The empirical findings also contribute to the understanding of how to enhance the industrial safety strategy for this industry that will assist in reducing these accidents and in redesigning the OHS framework in Bahrain. However, having the results of the case study from one of the strategic companies in O&G industry in Bahrain is favourable as it was applied directly on a real workplace by concentrating on the point of views of the managerial and operational levels of this company. Apart from all that, this research also ensures the resilient and sustainable future of this industry and supports the long-term planning of it.

Within this chapter, the most essential results are synthesised and concluded. In addition, the structure of this chapter presents the limitations of this study and the contribution of the research to practice and theory and further research and new directions. Finally, final note is discussed.

6.2 Summary of Key Findings

This research is considered as the first of its kind in its seeking to understand the human error accidents in O&G industry in Bahrain and the main related challenges to these accidents in order to enhance the industrial safety strategy. This research concerns on gathering and collecting the required information directly from the managerial and operational level in this industry. This provides a unique and broader understanding regarding some latent or experienced problems. This section provides a summary of the important outcomes of this research in regard to each objective.

6.2.1 Research Objective 1: To define human errors and human factors within the context of accidents in general.

This objective was introduced in Chapter 1 and comprehensively was discussed in the literature review in Chapter 2. In order to acquire a better understanding on human error accidents, it is immensely important to establish a simple definition of 'human error' and the role of human error in contributing to accidents. Human error is a significant cause of accidents. Human error is an improper decision or behaviour of a worker which may has a negative impact on the effectiveness of safety performance system (Jahangiri et al., 2016). It also can be viewed as a negative result from the gap between human capacities and the demand of processes and procedures in a workplace. However, some authors indicated that human error is the 'fault' of someone at the sharp end which may be the last person who touched the equipment. Further, this research finds two classification for human error which are Reason's (1990) classification and Kontogiannis and Embreys's (1992) classification. According to Reason (1990), human error is the failure of planned actions to reach the desired aim. It is divided into three main categories as slip, lapse and mistake. While according to Kontogiannis and Embrey (1992), human error is divided into six types which are action, checking, retrieval, transmission, diagnostic and decision errors. On top of that, human factors also described in this research. Human factors is a broader concept that include environment, organisation, job factors workplace and human with individual characteristics. Addressing human factors in a workplace has many positive improvements in maintainability, reliability and availability of systems, productivity, training quality and the overall performance. Example of most critical human factors are like poor role of top management, poor safety leadership, poor safety culture, poor design of workplace, defective machinery, ineffective reporting system, improper technology, stress, low level of education, improper training and lack of multi-professional approach.

As 'human error' can be interpreted in many ways. In this study, the researcher defines it as an unintended failure of achieving the planned outcomes in a form of action, checking, retrieval, transmission, diagnostic and decision errors. Thus, this definition has four main characteristics which are there was no intention to commit an error, the action was purposeful, the action was action error, checking error, retrieval error, transmission error, diagnostic error or decision error and the intended outcome was not achieved. From the managerial point of view, human error is a negative act or action that leads to harm to workers and losses in workplace and environment. Human error is the cause of most of accidents in O&G industry in Bahrain. Human errors accidents are common and they can be a form of low safety behaviour. Additionally, there are different examples of human error accidents like overconfidence, ignoring the importance of wearing PPE, loss of focus, lack of judgment, shortcut and carelessness. Overconfidence and ignoring the importance of wearing PPE are the most common examples.

6.2.2 Research Objective 2: To identify the current OHS legislation, regulations and implementation in O&G industry in Bahrain.

This objective was addressed in the Literature Review in Chapter 2, the case study analysis and cross-case analysis in Chapter 4. OHS framework in O&G industry is a combination of internal and external legislations and regulations requirements and industry specific requirements. It should cover most critical aspects of workplace in O&G industry. The first OHS legislation in Bahrain was based on the UK Health and Safety at Work Act 1974. It provides the necessary precautions to protect workers from the hazards and risks. OHS framework consists of numbers of regulations and orders regarding workers' protection, workplace safety, safety inspection, precautionary and preventative control measures and environmental concerns. In addition, NOGA had implemented also a variety of safety policies to control the working conditions and ensure safe and environmentally friendly practices for the operations in O&G industry. Most of regulations and orders in this framework were developed generally to all industries in Bahrain with both private and public entities. There is no ongoing dedicated orders for the O&G industry specifics for example for the exploring, drilling and processing of O&G and even for the construction and operation of O&G pipelines. This framework confronts a lack of safety professionals who address the conflict between market trend and OHS regulatory requirements. Apart from that, the results of the semi-structured interviews were different. Some interviewees pointed out that the existing OHS framework is better than the last 5 years while the majority of the interviewees noted that still the current OHS framework needs more coordinating, restructuring and redesigning efforts. They confirmed that OHS framework needs specific regulations that should be proposed to O&G industry's setting aligning with the global changes in this industry. Additionally, other interviwees pointed that this need should be addressed and solved urgently especially after the largest new oil discovery in Bahrain. Besides, several interviewees highlighted the need for a special regulatory body to coordinate and oversee the overall OHS framework in O&G industry in Bahrain. As the current OHS framework needs to be enhanced and modified, the final industrial safety strategy can address that. It is not the perfect comprehensive solution, but it does provide a means to tackle the current challenges in O&G industry satisfactorily in the immediate future. Another ultimate aim of the current thesis, which is considered as one of the general contributions, is the improvement of safety regulations, operations, policies and practices in this industry through a strategic perspective.

6.2.3 Research Objective 3: To critically evaluate the challenges related to human errors specific accidents in O&G industry in Bahrain.

This objective was addressed mainly in the research results and analysis in Chapter 4 through the case study anlysis, cross-case analysis and documents analysis. This objective has been achieved by considering two points of view which are the managerial level point of view and operational level point of view. Based on the managerial level point of view in the three units, there are eight challenges related to human error accidents. These challenges are safety bahaviour, safety training, accidents reporting system, role of safety leadership, safety culture, safety implementation, communication and role of top management. All interviewees confirmed that safety training is the most critical challenges. On the other hand, there are six challenges related to human error accidents based on the operational level point of view which are safety training, safety implementation, accidents reporting system, communication, safety regulation and safety leadership. Accordingly, results from the analysis of the two sets of data highlight in total nine challenges in which they agree on five challenges which are safety training, safety implementation, accidents reporting system, communication and safety leadership and differ in four challenges which are safety bahaviour, safety culture, role of top management and safety regulation. However, there is a notable high consensus that safety training and accidents reporting system are the top two challenges by agreement between the managerial and operational levels in the three units.

Grouping by some demographics factors like work schedule and work location, different quantitative results were identified using the Mann-Whitney U test on the agreement on the challenges in each unit. For example, regarding the agreements on the safety training as a challenge related to human error accidents, results of the Mann-Whitney U test revealed that shift schedule employees had significantly greater results than for fixed schedule employees in the three units. Likewise, results showed that outdoor employees had significantly greater results than for indoor employees in the three units. On the other hand, regarding the agreements on the accidents reporting system as a challenge related to human error accidents, results of the Mann-Whitney U test revealed that shift schedule employees had significantly greater results than for fixed schedule employees in the refining and distributing units while there was no difference between these two groups in the storage unit. Likewise, results showed that outdoor employees had significantly greater results than for indoor employees in the refining and distributing units while there was no difference between these two groups in the storage unit. Apart from all that, all challenges should be given a great attention to contribute significantly to reducing the probability of human error accidents. All these challenges are considered in the final industrial safety strategy.

6.2.4 Research Objective 4: To explore best safety practices from other O&G industries in developed and industrial countries.

This objective was well-developed and discussed in the literature review of Chapter 2 and in results and analysis of the qualitative data of the interviews in Chapter 4. Committing to safety best practices in O&G industry is critical. A best practice is a successful technique or method that was resulted from others experience and research. Sharing these best safety practices is required to benefit more people. It is important to ensure that the adapted best safety practices promote efficiency, effectiveness, ethical soundness, relevance, sustainability and possibility of duplication, the participation of partners and the community and political commitment (WHO, 2017). This indicates that selecting best safety practices for O&G industry should involve judgement and prior analysis. In the Literature Review in Chapter 2, several examples of safety best practices in O&G industry were presented. For instance, safety best safety practices of HSE (2006) in UK which emphasise on seven essential aspects in the industry such as manager roles and responsibilities, manager competence, implications, culture, standards and values, internal controls, performance management and organisational structures. On the other hand, a broader view of safety best safety practices was found in ISHN (2014) in UK which identified 20 best practices in O&G industry. Moreover, Kenyon (2014) has indicated that onboarding and ongoing training, quality training, staying up-to-date on safety regulations and consistent communication are the four mandatory best safety practices in O&G industry. All these best safety practices and others that were mentioned in Chapter 2 strongly improve the overall safety performance in O&G industry.

Turning to the adapted safety best practices in O&G industry in Bahrain, the findings obtained in Chapter 4 confirm the importance of these best practices in improving the performance in each unit and in ensuring a high level of safety for the workers, workplace and environment in each unit. Results also indicate that internaltional there are many best practices but selecting the appropriate one should be done after systematic assessments and evaluations with the current sitaotion of each unit. In O&G industry in Bahrain, there are two main types of best safety practices that are adapted. The first one is Operational Excellence utilising the experiences of Chevron while the second is Solomon's Fuels Study. Finally, most of interviewees pointed that O&G industry in Bahrain should pursuing hardly toward more effective best safety practices.

6.2.5 Research Objective 5: To refine and validate the recommendations of the industrial safety strategy for the O&G industry in Bahrain

This objective was addressed clearly in Chapter 5 utilising from results of literature review in Chapter 2 and of the results of the research analysis in Chapter 4. Developing an industrial safety strategy in O&G industry in Bahrain is simply adding useful changes in the industry aligning with better coordinations of the main critical components in the workplace. All Bahraini government, O&G industry, workers, partnerships, contractors and other stakeholders are responsible for the success of this strategy. The vision of this strategy is building a healthy, safe and profitable workplace. This vision will be derived by four main outcomes. These outcomes are reducing human error accidents, reducing exposure to hazards and risks, improving workplace safety and OHS framework and improving human resources management. Based on these outcomes, several results will be noticed like a decrease in human error accidents, an increase in the number of workers who have the right training programmes and an increase in safety awareness and commitment. In order to achieve the vision and outcomes of this strategy, O&G industry should place attention to the nine important action areas that are designed. These areas are selected based on the empirical results in Chapter 4. These action areas are accidents reporting system, safety leadership and safety culture, safety training and competence, communication and engagement, safety authority, OHS framework and safety compliance, workplace design and risk management techniques, technology and research and development. O&G industry should understand the boundaries and effect of each area and how these areas will contribute to the overall OHS performance in this industry. To simplify the understanding of this strategy, a presentation of the final refined strategy have been implemented. The refining and validation process depended on the feedbacks of five experts, who have a reliable experience in O&G industry and accidents management fields.

6.3 Limitations of this Study

Any research may confront with some limitations or barriers during any phase of research lifecycle. This section presents main limitations that were inherited to the current research. The first limitation is during the first phases of research and related to the fact that there is an absence of scientific research or studies about human error accidents in O&G industry and there is a lack of media coverage due to confidentiality issue. Thus, there is a lack of reliability of the available safety data and resources. On the other hand, there is no enough published information or accessible databases to collect information about the history of safety in these workplaces.

Another limitation is related to the fact that this research attempts to enhance the industrial safety strategy for O&G industry in Bahrain by considering human attributed accidents and its related key concepts from three units of the downstream of a core company within this industry. Therefore, the resulted strategy of this research represents a specific and unique context of the downstream of one Bahraini company in which transferring an identical copy of this strategy to other developing countries could be difficult. This means that it may be hard for other researchers to apply the findings to their own work. This does not indicate that the resulted empirical findings in the current research are invalid instead they emphasised on certain circumstances found in the three units. Consequently, it is important to reach the academic curiosity's satisfaction by expanding this research to the overall industry and to other companies in Bahrain. Additionally, having a wider scope would be an interesting extension to include more organisations within GCC countries that have aced in their experience in this industry, however, it would be also interesting to expand it to other developing countries in order to further emphasise on cross-cultural influences. This means that it is recommended to replicate this research regionally and internationally to enable better generalisability of the findings of the research.

Finally, the last limitation is related to the fact that the international OHS requirements are changing rapidly and dynamically. This means that the presentation and components of the developed strategy do not suggest that legislations and regulations have stopped changing. For example, new legislations and regulations are required in the current market that should be adapted in this industry in the coming short period. Thus, the new requirement would represent an opportunity for studying. Likewise, more advanced tools and technologies will be released in markets and might be adapted in O&G industry as it has new ways to conduct the tasks in the workplaces more effectively and efficiently. And simply this would be an opportunity for studying this research with better insights.

6.4 Contributions of the Study

This thesis tends to highlight some concerns related to human error accidents and its main challenges in order to help in building an action plan for enhancing the industrial safety strategy by reducing these accidents that result in different losses in the industry. Moreover, this research has added several contributions practically and theoretically. These contributions are discussed in the next sub-sections.

6.4.1 Practical Contributions

The findings of the research provide several practical contributions. These contributions provide a broader insight of the phenomena. However, there are some obscure lessons that do not exist or have not been identified directly from the theoretical stance instead they present valuable clearly after describing and illustrating it practically via methods that build accurate understanding. Thus, the current research, which is derived from fieldwork, provides a broad understanding by focusing on the three units in the downstream and represents as important guidance and methodological steps to enhance the industrial safety strategy in O&G industry in Bahrain for the mid- term to long-term strategic planning. Collecting data from different units that have different context, tasks, and environment helps in drawing a holistic picture regarding the scenarios of human error accidents and the main related challenges. On top of that, as this research relies on several relevant literatures regarding this phenomena, all that practically implies to build an effective and integrated action plan for enhancing the industrial safety strategy that has been refined and validated comprehensively. This strategy is a practical tool or guidance for the company and the overall O&G industry in Bahrain that highlights key insights, information and requirements that could be used to improve the existing OHS framework and the structure of the current industry as well. For example, the definition of human error accidents can guide practitioners in addressing the issue. On top of that, the main challenges related to human error accidents that are identified in this research should be taken into consideration of this industry to address them precisely and to better communicate alternative solutions. This means that these challenges can guide practitioners in developing more tools and techniques that overcome these challenges in order to avoid or to reduce the possibility of human error accidents. Finally, the findings of this research also are valuable information which easily can be transferred practically for the social actors in this industry.

6.4.2 Theoretical Contributions

The findings of the research provide major theoretical contributions as well. First, prior literature in the area of human error mainly investigated the Nuclear, Aviation and construction industries and few studies till date have focused on this issue within the O&G industry. As a mean of illustration, there was a lack of the available academic resources into human error accidents particularly in O&G industry. The current research extends the understanding of human error accidents literature by focusing on this industry and especially on the downstream. For instance, the results throw light on the definition and description of the setting of this type of accidents. Second, this research has contributed to theory as it is considered as the first of its kind in this industry regionally that provides data and accessible information regarding this issue and identifies the challenges related to human error accidents from two critical point of views which are the managerial level and the operational level of the downstream. This means that this research gives professionals and academics alike a unique view to some critical latent issues and phenomena that need to be considered comprehensively. In fact, the theoretical knowledge enclosed in this research represents cumulative and integrated results of a wide range of earlier studies regarding the current phenomena, confirms such information and puts it in one place. Undoubtedly, this will assist the development of extension or related research in the future, as the collecting reliable secondary sources is difficult. Lastly, this research with the applied data collection and analysis techniques can also help and support in conducting similar studies on other developing countries. Meanwhile, further research and new directions are discussed in the next section.

6.5 Further Research and New Direction

Several recommendations for further research are suggested in this section. Despite the challenges faced throughout this research, interested avenues for further investigations can be explored for researchers with the same line of research. Further research will help to understand human error accidents and its related issues and challenges in much wider and simpler manner which will encounter novel questions and search for answers of those questions will result in learning more new aspects of this issue. In other words, further research means trying something out of the box. Recently, O&G industry has launched different ICT-related initiatives. Thus, it was important to conduct empirical studies to understand the impact of the adoption and use of these ICT-related initiatives on reducing human error accidents. Besides that, an interesting extension of this research would be a cross-country comparison research to identify common and disparate factors and aspects related to enhancing the industrial safety strategy that considers human attributed accidents. Therefore, it is a good opportunity for researchers to carry out a research with this need.

Researchers can also have an interesting research that compares the result of enhancing the industrial safety strategy regionally in GCC Countries to the result of several international O&G industries. Additionally, one of the shortcoming of the current study is that the final industrial safety strategy determined by the study has not been tested in term of applicability and practical implications because this is beyond the scope of this doctoral study. Thus, it will be valuable to apply this final strategy in the selected company or units to test its validity in practice. This contribution may be considered as an attractive research objective for researchers. Lastly, there are several other methods available for assessing the challenges that are related to human error accidents; thereby, it would be interesting to conduct research by implementing other advanced analyses and methods.

6.6 Final Note

This chapter summarised the main conclusions of the whole study from the literature review, semi-structured interviews, and questionnaire surveys and demonstrates how aim and objectives have been fulfilled. The primary outcome of the study is an industrial safety strategy by considering human attributed accidents. Thus, the results of this research contributes the theory and practice of human error accidents in O&G industry. Although some limitations were revealed to the study, the researcher has taken greatest effort to avert their consequences. This chapter also suggests recommendations for future work. Finally, the outcome of this research is an opportunity that opens doors for further research areas in terms of context, focus and application.

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APPENDICES

APPENDIX 1: LIST OF PUBLICATIONS

Refereed Conference Publications

- Alkhaldi, M., Pathirage, C., & Kulatunga, U. (2017, September). The role of human error in accidents within oil and gas industry in Bahrain. In *13th International Postgraduate Research Conference (IPGRC): conference proceedings* (pp. 822-834). University of Salford.

- Alkhaldi, M. & Pathirage, C. (2018, December). Challenges of Human Error Related Accidents in the Oil and Gas Industry in Bahrain. *In 1st International Conference on Construction Futures.* University of Wolverhampton.

Refereed Conference Posters

- Alkhaldi, M., Pathirage, C., & Kulatunga, U. (2017, September). Critical Review of Occupational Accidents Data and Statistics in Oil and Gas Industry in Bahrain. In *13th International Postgraduate Research Conference (IPGRC): Poster*s. University of Salford.

APPENDIX 2: PARTICIPANT INFORMATION SHEET

Title of the Research Study: 'Impact of Human Errors on Accidents in the Oil and Gas Industry in Bahrain'

Name of the Researcher: [………]

Names of the Supervisors: [………]

Aim of the study:

The aim of this research is to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan.

This study has been approved by their employers in Company A and Bahrain's Civil Defence in their monitoring capacity.

Why have I been chosen?

The research focus is on the current human error accidents and human factors in the O&G industry in Bahrain. As such, the researcher seeks to gain further understanding of these contexts along with the current OHS practices, legislation, regulations and challenges in order to enhance the industrial safety strategy in the O&G industry in Bahrain that addresses that. Your expertise and knowledge in this area makes it vital for this research study which will aid the researcher in achieving the research aim.

Do I have to take part?

Participation in this research is entirely voluntary and, as such, you can withdraw from the study at any stage. It is fully within your power to decide whether to participate or not in this research. Further information and explanations can be provided to you if it helps in making a decision on participation. If you agree to participate, a consent form will be given to you to sign. As stated, you are free to withdraw at any time, without giving a reason.

Should I decide to take part, what happens next?

Once you have made the decision to participate in the research, a questionnaire/interview guide will be sent to you to improve your perception about your involvement and to provide a broader insight about the type of questions that the researcher will ask. The researcher will happily answer any questions regarding the research. After the initial stage is completed, a suitable data, location and time for the interview will be arranged with yourself. If you have any questions about the research, the researcher will be very happy to answer them and satisfy you.

What am I supposed to do if I become involved in the project?

After you accept to participate in the study, a consent form will be given to you to be signed to ensure your acceptance. Then, the relevant data collection instrument will be given to you to get your opinion and point of view regarding human error accident, human factors and OHS issues. The interview will take approximately 1 hour long and will be audio recorded with your permission. A questionnaire survey will take 20- 30 minutes. For the purposes of anonymity your real name or any other personal information will not be included at any phase of the study.

Will my taking part in this study be kept confidential?

The researcher will ensure a full confidentiality and protection of any data and information. All the data obtained from the interview will be kept confidential and secure to maintain anonymity. Codes and numbers will be used as identifiers but otherwise no information will be presented at any stage that will identify the participant. No personal information of the participant will be allocated as an identifier. Moreover, the recorded interview will be transcribed anonymously and will be saved in a password protected computer that will only be accessed by the researcher. The collected data will then be used as part of the final thesis and any related publications. Access to the data will be available to the research supervisory team, however, the names will remain anonymous. However, all the collected data would be securely stored for up to 3 years after the PhD award has been issued to comply with the data retention policy of the University of Salford. After completing this period, all of the data can be destroyed securely to comply with data protection and maintaining confidentiality.

What are the potential benefits of participating?

Your knowledge and professional expertise in the field of human error accidents and OHS is a vital contribution to enhance the industrial safety strategy in the O&G industry in Bahrain. Such improvement and recommendations will be beneficial for this industry in this manner.

What will happen to the results of the research study?

The results of the research will be interpreted in the light of the facts to compile findings and enhance a strategy and writing up of PhD thesis. Besides, the research findings will be presented and published in related fields such as in academic journals, conferences and seminars. Nevertheless, the results and findings may be shared with other researchers and practitioners. Where the results of the research will be used, the details of the participants will always remain anonymous unless you have given a written consent to disclose the information.

Is there any risk involved?

Based on the nature of the research, participants will not be exposed to any form of risk.

Will the participant get paid?

Participation in the research is voluntary and, as such, there is no financial incentive involved with the study.

Additional Information:

The researcher is a PhD student at the School of Built Environment, University of Salford. If you require any further information or you have any enquiries about this research or your participation, please don't hesitate to contact.

Contact details:

If you have any questions about this study, you can contact the person(s) below:

Researcher: [............] xyz@edu.salford.ac.uk

Supervisor: [............] xyz@salford.ac.uk

I hope you will be interested in this research study and your participation will be very much appreciated. Thank you very much for your time and consideration.

Kind regards,

[.........]

APPENDIX 3: QUESTIONNAIRE

Section 1: Participant's Background Information [Please tick the appropriate answer]

1) Age

☐ 20- 30 ☐ 30- 40 ☐ 40- 50 ☐ 50- 60 ☐ Over 60

2) Occupation

3) Experience in the Oil and Gas industry

☐ 0- 5 yrs ☐ 6- 10 yrs ☐ 11- 15 yrs ☐ More than 15 yrs

Section 2: Workplace Information

1) Type of work schedule

☐ Fixed ☐ Shifts

2) How many are your weekly working hours (including overtime)?

☐ 40-49 hrs ☐ 50-59 hrs ☐ _____ hrs

3) Safety qualifications

4) Level of risk in your workplace

☐ Low ☐ Medium ☐ High

5) Need of Personal Protective Equipment (PPE) in your job

☐ Sometimes ☐ Always

6) Work location

☐ Indoor ☐ Outdoor

7) Noise level

☐ Low ☐ Medium ☐ High

8) Clarity of the communication language between different workers

☐ Bad ☐ Medium ☐ Good

Section 3: Opinions on your workplace

[Please tick the appropriate answer to indicate the range on how strongly you agree or disagree or tick 3 if you feel indifferent]

Construct	Item	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
		1	2	3	4	5
Safety regulation	**1.** Safety policy ensures OHS and well-being of workers.					
	2. Safety policy is updated and improved regularly.					
	3. Safety policy, principles of action and objectives are written and documented.					
	4. Safety policy, standards and rules are clear to all workers.					
	5. Instruction manuals that elaborated to aid in preventive action are available to all.					
Safety implementation	**1.** Safety plays a key role in job promotions.					
	2. The safety procedures and practices in this organisation are valuable and effective.					
	3. There are periodical safety inspections for all workplaces.					
	4. The safety rules and procedures assist in preventing accidents in the workplace.					

Top management	**1.** Managers and supervisors often try to enforce safe working procedures.					
	2. Management regularly consults with employees about OHS issues in the workplace.					
	3. Safety committees exist in my company consisting of representatives of the managerial and operational levels.					
Safety training	**1.** There is a sufficient training period for new employee, any change in the workplace or using new equipment.					
	2. Safety training is updated regularly and the training programme is well-organised.					
	3. Workers are satisfied with the acquired educational level from training, as it will raise their job performance level.					
Safety leadership	**1.** Management inspires all employees to attend safety-training courses.					
	2. Management stimulates employees' involvement in OHS matters.					
	3. Managers are active and visible in addressing OHS matters.					
	4. Managers always visits the workplace to ensure safe working conditions and communicate with workers.					
Communication	**1.** There are regular meetings, sessions, or oral presentations to transfer safety standards and rules of action.					
	2. Workers on this unit always ask another worker when they do not understand what to do.					

	3. Workers on this unit will continue to seek clarification/question the safety leadership when an order does not quite make sense.					
	4. Management allows workers to state their opinion before taking decisions on OHS matters.					
Accidents reporting system	**1.** In my company, accident report is mandatory even if there is no injuries or damages.					
	2. In my company, accident investigation results are always shared among all workers.					
	3. In my company, recommended actions in accidents investigation reports are always taken place after accident.					

APPENDIX 4: INTERVIEW GUIDELINES

1. Participants position, professional background, experience in the Oil and Gas industry and unit overview.

2. General overview regarding safety, OHS framework, OHS legislation and regulations in the O&G industry.
    - Safety in the O&G industry
    - Risk level, with reasons
    - Thoughts and opinions of the existing OHS framework in this industry
    - Compliance
    - Recommendations for improvements

3. Defining human error accidents in this industry
    - Definitions
    - Scenario or examples of these accidents

4. Thoughts and opinions of the challenges related to human errors specific accidents in the O&G industry in Bahrain.
    - Challenges that contribute to these accidents
    - Recommendation for overcoming these challenges

5. Thoughts and opinions of implementing best safety practices from other O&G industries in the developed and industrial countries.
    - Examples
    - Benefits and limitations

6. Thoughts and opinions of formulating safety strategy for the Oil and Gas industry in Bahrain
    - Overview of the existing one
    - Benefits and limitations
    - Recommendations

APPENDIX 5: CONSENT FORM FOR QUESTIONNAIRE PARTICIPANTS

The purpose of this survey is to enhance the industrial safety strategy by considering human attributed accidents in the O&G industry in Bahrain through developing an action plan. This study has been approved by the employers of Company A and Bahrain's Civil Defence in their monitoring capacity.

You are invited to participate in this study due to your work experiences and knowledge in the downstream of the O&G industry in Bahrain. Participation in this research is entirely voluntary and you can choose to not take part in the study However, your participation in the research will be beneficial. If you participate, you can withdraw from the research at any time of the study without giving any reason.

Participation in the research involves completing the questionnaire that will take 20-30 minutes. Your responses will be confidential and any personal information such as your name and others will always be kept secure and confidential.

Questions will be about human error accidents and OHS issues. In addition, this will involve challenges related to human errors specific accidents in the O&G industry.

All data obtained from the survey will be secured in a locked cabinet. The results will be maintained for academic purposes and shared with the University of Salford where it will be held confidentiality.

If you have any further questions about the research, please do not hesitate to contact the researcher.

Consent Statement:

I have read and understood the information about the research and I consent to participate in this study *

Yes ☐

No ☐

APPENDIX 6: CONSENT FORM FOR INTERVIEW PARTICIPANTS

Title of the Research Study:	As this research has been accepted and confirmed to be undertaken by Bahrain's Civil Defence and Company A, the title of this study is proposed as "Impact of Human Errors on Accidents in the Oil and Gas Industry in Bahrain."
Researcher's Name:	[…………]
Supervisory Team:	[…………]

Note: This study has been approved by the employers of Company A and Bahrain's Civil Defence in their monitoring capacity .

Please tick the appropriate boxes	**Yes**	**No**
Taking Part		
I have read and understood the project information sheet dated DD/MM/YYYY.	☐	☐
I have been given the opportunity to ask questions about the project.	☐	☐
I agree to take part in the project. Taking part in the project will include being interviewed and audio – recorded.	☐	☐
I understand that my taking part is voluntary; I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to take part.	☐	☐
Use of the information I provide for this project only		
I understand my personal details such as phone number and address will not be revealed to people outside the project.	☐	☐
I understand that my words may be quoted in publications, reports, web pages, and other research outputs.	☐	☐

*Please choose **one** of the following two options:*

I would like my real name used in the above ☐

I would **not** like my real name to be used in the above. ☐

______________________________ _________________________ ____________

Name of participant [printed] Signature Date

______________________________ _________________________ ____________

Researcher [printed] Signature Date

Project contact details for further information:

Researcher [............] xyz@edu.salford.ac.uk

Supervisor [............] xyz@salford.ac.uk

APPENDIX 7: ETHICAL APPROVAL

University of Salford
MANCHESTER

Research, Innovation and Academic Engagement Ethical Approval Panel

Research Centres Support Team
G0.3 Joule House
University of Salford
M5 4WT

T +44(0)161 295 5278

www.salford.ac.uk/

19 May 2017

Musab Alkhaldi

Dear Musab,

RE: ETHICS APPLICATION ST1617-60 - Impact of Human Errors on Accidents in Oil and Gas Industry in Bahrain

Based on the information you provided, I am pleased to inform you that your application ST1617-60 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

Dr Anthony Higham
Chair of the Science & Technology Research Ethics Panel

APPENDIX 8: USEFUL TERMS

- American Petroleum Institute (API) is the only national trade association that represents all aspects of America's oil and natural gas industry. it consists of 650 corporate members from all segments of the industry which are producers, refiners, suppliers, marketers, pipeline operators and marine transporters, as well as service and supply companies that support all segments of the industry.

- Bahrain Economic Development Board (BEDB) is a dynamic public agency with the overall responsibility for attracting investment into Bahrain and supporting initiatives that enhance investment climate.

- Bahrain News Agency (BNA) is the state news agency of Bahrain and it was established in 1976.

- Det Norske Veritas and Germanischer Lloyd (DNV.GL) aims to promote safeguarding life, property and the environment and enable organisations to advance the safety and sustainability of their business. It provides also classification and technical assurance along with software and independent expert advisory services to the maritime, oil & gas and energy industries. Additionally, it provides certification services to customers across a wide range of industries.

- Economist Intelligence Unit (EIU) is a business within The Economist Group providing forecasting and advisory services through research and analysis, such as monthly country reports, five-year country economic forecasts, country risk service reports, and industry reports. The EIU provides country, industry, and management analysis worldwide and incorporates the former Business International Corporation.

- Energy Information Administration (EIA) is a government agency to advice the U.S. Department of Energy and it was formed in 1977. It is responsible for objectively collecting energy data, conducting analysis and making forecasts.

- Free Trade Agreement between United States and Bahrain (United States-Bahrain FTA) was entered into force on January 11, 2006. It generates export opportunities for the United States, creating jobs for U.S. farmers and workers. The agreement also supports Bahrain's economic and political reforms and enhances commercial relations with an economic leader in the Arabian Gulf.

- Gulf Cooperation Council (GCC) is a political and economic alliance consists of six Middle Eastern countries which are Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman. It was established in May 1981in Riyadh, Saudia Arabia. The aim of the GCC is to achieve unity among members based on their common objectives and political and cultural identities, which are rooted in Islamic beliefs.

- Industrial Safety Hygiene News (ISHN) is delivered monthly to 71400 safety and health professionals who direct safety and health programs in high-hazard workplaces. It is consistently ranked as the most useful media brand serving environmental health and safety professionals. It reaches key safety, health and industrial hygiene buying influencers at manufacturing facilities of all sizes.

- International Labour Organisation (ILO) is established to promote social justice and internationally recognised human and labour rights and pursue its founding mission that social justice is essential to universal and lasting peace. It was created in 1919, as part of the Treaty of Versailles that ended World War I, to reflect the belief that universal and lasting peace can be accomplished only if it is based on social justice.

- Lawyers & Settlements is the anchor publication of Online Legal Media--on the web since 2001. It presents an independent voice for the public and maintains a balanced approach to reporting on key legal issues.

- Middle East is a geographical and cultural region located primarily in western Asia, but also in parts of northern Africa and southeastern Europe.

- Ministry of Labour (MOL) is responsible for providing job opportunities for Bahrainis of both sexes. It has also taken the initiative of establishing departments and directorates to be concerned with work and workers' issues, and developing plans and programmes in order to improve the abilities and efficiencies of the Bahraini worker so that he can participate effectively in the social development plans. It concerns also on labor laws and regulations and labor protection activities.

- National Examination Board of Occupational Safety and Health (NEBOSH) is an awarding body with charitable status and it was formed in 1979. The purpose of this body is offering a comprehensive range of globally-recognised qualifications designed to meet the health, safety and environmental management needs of all places of work.

- National Institute for Occupational Safety and Health (NIOSH) is part of the U.S. Centers for Disease Control and Prevention, in the U.S. Department of Health and Human Services. The Occupational Safety and Health Act of 1970 established NIOSH. It has the mandate to assure that all men and women in the Nation safe and healthful working conditions and to preserve human resources. It works closely with the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration in the U.S. Department of Labor to protect American workers and miners.

- Organisation of the Petroleum Exporting Countries (OPEC) is a permanent, intergovernmental Organisation, created on September 10–14, 1960 at the Baghdad Conference, by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. The objective of OPEC is to co-ordinate and unify petroleum policies among members, in order to secure fair and stable prices for petroleum producers; an efficient, economic and regular supply of petroleum to other nations; and a fair return on capital to those investing in the industry.

- Risktec Solutions is an established, independent and specialist risk management consulting and training company. It assissts clients in major hazard industries and commercial and public sectors to manage health, safety, security, environmental (HSSE) and business risk.

- Rural Planning Services Group (RPSG) is an international consultancy that provides advices upon the development and management of the built and natural environment, the planning and development of strategic infrastructure and the evaluation and development of energy, water and other resources.

- Saylor Academy is a non-profit organisation headquartered in Washington, DC. It was established in 1999. The focus of the foundation has been its Free Education Initiative which has led to the creation of 241 courses representing 10 of the highest enrollment majors in the US. *Thus, it* provides free and open online courses and affordable college credit opportunities to learners everywhere.

- Social Insurance Organisation (SIO) is an official authority in Bahrain that is responsible for providing social insurance services to all people covered by Pension Civil Law and Social Insurance Law in the Kingdom of Bahrain against risks of aging, disability, death, work-related injuries, and unemployment in both public and private sectors.

- World Bank Group (WBG) is a unique partnership to reduce poverty and support development. The World Bank Group comprises of 189 member countries. It is an important source of financial and technical assistance to developing countries around the world.

- World Trade Organisation (WTO) is the only global international organisation dealing with the rules of trade between nations. It provides a forum for negotiating agreements aimed at reducing difficulties to international trade and ensuring a level playing field for all, thus contributing to economic growth and development. Additionally, it provides a legal and institutional framework for the implementation and monitoring of these agreements, as well as for settling disputes arising from their interpretation and application.

APPENDIX 9: SPREADSHEET FOR REFINING UNIT

Items	S/D	D	N A/D	A	S/A	M	SD	Result
1. Safety policy ensures OHS and well-being of workers.	15.8%	19.3%	8.8%	42.1%	14.0%	3.19	1.342	**Neither**
2. Safety policy is updated and improved regularly.	8.8%	24.6%	14.0%	40.4%	12.3%	3.23	1.210	**Neither**
3. Safety policy, principles of action and objectives are written and documented.	7.0%	10.5%	7.0%	57.9%	17.5%	3.68	1.105	**Agree**
4. Safety policy, standards and rules are clear to all workers.	7.0%	1.8%	3.5%	68.4%	19.3%	3.91	0.969	**Agree**
5. Instruction manuals that elaborated to aid in preventive action are available to all.	14.0%	14.0%	22.8%	33.3%	15.8%	3.23	1.282	**Neither**
Safety_regulation						**3.45**	**0.772**	**Agree**
1. Safety plays a key role in job promotions.	33.3%	36.8%	22.8%	7.0%	0%	2.04	0.925	**Disagree**
2. The safety procedures and practices in this organisation are valuable and effective.	14.0%	42.1%	26.3%	17.5%	0%	2.47	0.947	**Disagree**
3. There are periodical safety inspections for all workplaces.	26.3%	24.6%	29.8%	15.8%	3.5%	2.46	1.151	**Disagree**
4. The safety rules and procedures assist in preventing accidents in the workplace.	38.6%	17.5%	14.0%	19.3%	10.5%	2.46	1.440	**Disagree**

Safety_implementation						**2.35**	**0.754**	**Disagree**
1. Managers and supervisors often try to enforce safe working procedures.	7.0%	15.8%	5.3%	50.9%	21.1%	3.63	1.190	**Agree**
2. Management regularly consults with employees about OHS issues in the workplace.	10.5%	10.5%	19.3%	42.1%	17.5%	3.46	1.211	**Agree**
3. Safety committees exist in my company consisting of representatives of the managerial and operational levels.	10.5%	7.0%	21.1%	52.6%	8.8%	3.42	1.101	**Agree**
Top_management						**3.50**	**1.022**	**Agree**
1. There is a sufficient training period for new employee, any change in the workplace or using new equipment.	36.8%	15.8%	8.8%	28.1%	10.5%	2.60	1.486	**Disagree**
2. Safety training is updated regularly and the training programme is well-organised.	28.1%	28.1%	12.3%	26.3%	5.3%	2.53	1.297	**Disagree**
3. Workers are satisfied with the acquired educational level from training, as it will raise their job performance level.	28.1%	35.1%	15.8%	12.3%	8.8%	2.39	1.264	**Disagree**
Safety_training						**2.50**	**1.158**	**Disagree**
1. Management inspires all employees to attend safety-training courses.	31.6%	22.8%	12.3%	24.6%	8.8%	2.56	1.389	**Disagree**

2. Management stimulates employees' involvement in OHS matters.	29.8%	31.6%	14.0%	19.3%	5.3%	2.39	1.250	**Disagree**
3. Managers are active and visible in addressing OHS matters.	26.3%	12.3%	22.8%	29.8%	8.8%	2.82	1.351	**Neither**
4. Managers always visits the workplace to ensure safe working conditions and communicate with workers.	22.8%	40.4%	7%	29.8%	0%	2.44	1.150	**Disagree**
Safety_leadership						**2.55**	**1.119**	**Disagree**
1. There are regular meetings, sessions, or oral presentations to transfer safety standards and rules of action.	0%	50.9%	26.3%	22.8%	0%	2.72	0.818	**Neither**
2. Workers on this unit always ask another worker when they do not understand what to do.	17.5%	82.5%	0%	0%	0%	1.82	0.384	**Agree**
3. Workers on this unit will continue to seek clarification/question the safety leadership when an order does not quite make sense.	21.1%	40.4%	38.6%	0%	0%	2.18	0.759	**Disagree**
4. Management allows workers to state their opinion before taking decisions on OHS matters.	57.9%	42.1%	0%	0%	0%	1.42	0.498	**Strongly Disagree**
Communication						**2.03**	**0.436**	**Disagree**
1. In my company, accident report is mandatory even if there is no injuries or damages.	24.6%	26.3%	26.3%	12.3%	10.5%	2.58	1.281	**Disagree**
	24.6%	29.8%	21.1%	14.0%	10.5%	2.56	1.296	**Disagree**

2. In my company, accident investigation results are always shared among all workers. **3.** In my company, recommended actions in accidents investigation reports are always taken place after accident.	49.1%	22.8%	15.8%	7.0%	5.3%	1.96	1.195	**Disagree**
Accidents_reporting_system						**2.36**	**0.934**	**Disagree**

**DS= Strongly Disagree, D=Disagree, N A/D= Neither Agree nor Disagree, A= Agree, SA= Strongly Agree, M=Mean and SD=Standard Deviation.*

APPENDIX 10: SPREADSHEET FOR THE DISTRIBUTING UNIT

Items	S/D	D	N A/D	A	S/A	M	SD	Result
1. Safety policy ensures OHS and well-being of workers.	26.9%	15.4%	21.2%	36.5%	0%	2.60	1.232	**Disagree**
2. Safety policy is updated and improved regularly.	17.3%	50.0%	7.7%	7.7%	17.3%	2.58	1.348	**Disagree**
3. Safety policy, principles of action and objectives are written and documented.	32.7%	26.9%	17.3%	0%	23.1%	2.54	1.527	**Disagree**
4. Safety policy, standards and rules are clear to all workers.	21.2%	26.9%	25.0%	19.2%	7.7%	2.65	1.235	**Neither**
5. Instruction manuals that elaborated to aid in preventive action are available to all.	32.7%	38.5%	9.6%	13.5%	5.8%	2.21	1.210	**Disagree**
Safety_regulation						**2.53**	**0.925**	**Disagree**
1. Safety plays a key role in job promotions.	23.1%	40.4%	15.4%	11.5%	9.6%	2.44	1.243	**Disagree**
2. The safety procedures and practices in this organisation are valuable and effective.	36.5%	13.5%	25.0%	17.3%	7.7%	2.46	1.350	**Disagree**
3. There are periodical safety inspections for all workplaces.	13.5%	51.9%	19.2%	3.8%	11.5%	2.48	1.146	**Disagree**
4. The safety rules and procedures assist in preventing accidents in the workplace.	25.0%	26.9%	21.2%	15.4%	11.5%	2.62	1.331	**Neither**

Safety_implementation						**2.50**	**0.815**	**Disagree**
1. Managers and supervisors often try to enforce safe working procedures.	17.3%	30.8%	11.5%	21.2%	19.2%	2.94	1.420	**Neither**
2. Management regularly consults with employees about OHS issues in the workplace.	21.2%	34.6%	15.4%	17.3%	11.5%	2.63	1.314	**Neither**
3. Safety committees exist in my company consisting of representatives of the managerial and operational levels.	19.2%	26.9%	9.6%	25.0%	19.6%	2.98	1.448	**Neither**
Top_management						**2.85**	**0.993**	**Neither**
1. There is a sufficient training period for new employee, any change in the workplace or using new equipment.	25.0%	44.2%	11.5%	11.5%	7.7%	2.33	1.20	**Disagree**
2. Safety training is updated regularly and the training programme is well-organised.	21.2%	30.8%	15.4%	21.2%	11.5%	2.71	1.33	**Neither**
3. Workers are satisfied with the acquired educational level from training, as it will raise their job performance level.	38.5%	36.5%	11.5%	5.8%	7.7%	2.08	1.20	**Disagree**
Safety_training						**2.37**	**0.942**	**Disagree**
1. Management inspires all employees to attend safety-training courses.	0%	9.6%	7.7%	82.7%	0%	3.73	0.630	**Agree**

2. Management stimulates employees' involvement in OHS matters.	19.2%	0%	0%	38.5%	42.3%	3.85	1.474	**Agree**
3. Managers are active and visible in addressing OHS matters.	0%	13.5%	0%	63.5%	23.1%	3.96	0.885	**Agree**
4. Managers always visits the workplace to ensure safe working conditions and communicate with workers.	7.7%	23.1%	0%	69.2%	0%	3.31	1.076	**Neither**
Safety_leadership						**3.71**	**0.746**	**Agree**
1. There are regular meetings, sessions, or oral presentations to transfer safety standards and rules of action.	9.6%	32.7%	40.4%	13.5%	3.8%	2.69	0.961	**Neither**
2. Workers on this unit always ask another worker when they do not understand what to do.	13.5%	40.4%	23.1%	11.5%	11.5%	2.67	1.200	**Neither**
3. Workers on this unit will continue to seek clarification/question the safety leadership when an order does not quite make sense.	23.1%	34.6%	28.8%	9.6%	3.8%	2.37	1.067	**Disagree**
4. Management allows workers to state their opinion before taking decisions on OHS matters.	23.1%	42.3%	19.2%	9.6%	5.8%	2.33	1.115	**Disagree**
Communication						**2.51**	**0.708**	**Disagree**
1. In my company, accident report is mandatory even if there is no injuries or damages.	28.8%	32.7%	17.3%	11.5%	9.6%	2.40	1.290	**Disagree**
	23.1%	30.8%	25.0%	17.3%	3.8%	2.48	1.146	**Disagree**

2. In my company, accident investigation results are always shared among all workers. **3.** In my company, recommended actions in accidents investigation reports are always taken place after accident.	32.7%	25.0%	15.4%	17.3%	9.6%	2.46	1.364	**Disagree**
Accidents_reporting_system						**2.45**	**0.935**	**Disagree**

**DS= Strongly Disagree, D=Disagree, N A/D= Neither Agree nor Disagree, A= Agree, SA= Strongly Agree, M=Mean and SD=Standard Deviation.*

APPENDIX 11: SPREADSHEET FOR THE STORAGE UNIT

Items	S/D	D	N A/D	A	S/A	M	SD	Result
6. Safety policy ensures OHS and well-being of workers.	31.5%	35.2%	16.7%	7.4%	9.3%	2.28	1.250	**Disagree**
7. Safety policy is updated and improved regularly.	33.3%	33.3%	16.7%	9.3%	7.4%	2.24	1.228	**Disagree**
8. Safety policy, principles of action and objectives are written and documented.	27.8%	37%	22.2%	7.4%	5.6%	2.26	1.119	**Disagree**
9. Safety policy, standards and rules are clear to all workers.	16.7%	42.6%	25.9%	7.4%	7.4%	2.46	1.094	**Disagree**
10. Instruction manuals that elaborated to aid in preventive action are available to all.	31.5%	37.0%	11.1%	7.4%	13.0%	2.33	1.346	**Disagree**
Safety_regulation						**2.31**	**0.485**	**Disagree**
5. Safety plays a key role in job promotions.	0%	11.1%	9.3%	13.0%	14.8%	2.28	1.559	**Disagree**
6. The safety procedures and practices in this organisation are valuable and effective.	29.8%	0%	27.8%	0%	42.6%	2.26	1.696	**Disagree**
7. There are periodical safety inspections for all workplaces.	25.9%	40.7%	22.2%	7.4%	3.7%	2.22	1.040	**Disagree**
8. The safety rules and procedures assist in preventing accidents in the workplace.	53.7%	11.1%	9.3%	0%	25.9%	2.33	1.705	**Disagree**

Safety_implementation						**2.52**	**1.062**	**Disagree**
4. Managers and supervisors often try to enforce safe working procedures.	9.3%	24.1%	14.8%	20.4%	31.5%	3.41	1.394	**Agree**
5. Management regularly consults with employees about OHS issues in the workplace.	14.8%	13.0%	14.8%	24.1%	33.3%	3.48	1.450	**Agree**
6. Safety committees exist in my company consisting of representatives of the managerial and operational levels.	18.5%	5.6%	13.0%	31.5%	31.5%	3.52	1.463	**Agree**
Top_management						**3.47**	**1.207**	**Agree**
4. There is a sufficient training period for new employee, any change in the workplace or using new equipment.	33.3%	24.1%	16.7%	14.8%	11.1%	2.46	1.383	**Disagree**
5. Safety training is updated regularly and the training programme is well-organised.	42.6%	25.9%	13.0%	9.3%	9.3%	2.17	1.328	**Disagree**
6. Workers are satisfied with the acquired educational level from training, as it will raise their job performance level.	35.2%	29.6%	5.6%	18.5%	11.1%	2.41	1.421	**Disagree**
Safety_training						**2.34**	**1.231**	**Disagree**
5. Management inspires all employees to attend safety-training courses.	22.2%	37%	24.1%	9.3%	7.4%	2.43	1.159	**Disagree**

6. Management stimulates employees' involvement in OHS matters.	27.8%	29.6%	13.0%	16.7%	13.0%	2.57	1.395	**Disagree**
7. Managers are active and visible in addressing OHS matters.	24.1%	33.3%	14.8%	13.0%	14.8%	2.61	1.379	Neither
8. Managers always visits the workplace to ensure safe working conditions and communicate with workers.	27.8%	31.5%	18.5%	11.1%	11.1%	2.46	1.313	**Disagree**
Safety_leadership						**2.51**	**0.912**	**Disagree**
5. There are regular meetings, sessions, or oral presentations to transfer safety standards and rules of action.	22.2%	18.5%	13.0%	18.5%	27.8%	3.11	1.550	**Neither**
6. Workers on this unit always ask another worker when they do not understand what to do.	18.5%	24.1%	20.4%	25.9%	11.1%	2.87	1.304	**Neither**
7. Workers on this unit will continue to seek clarification/question the safety leadership when an order does not quite make sense.	37.0%	18.5%	18.5%	11.1%	14.8%	2.48	1.463	**Disagree**
8. Management allows workers to state their opinion before taking decisions on OHS matters.	16.7%	25.9%	14.8%	31.5%	11.1%	2.94	1.309	**Neither**
Communication						**2.85**	**0.902**	**Neither**
4. In my company, accident report is mandatory even if there is no injuries or damages.	37.0%	29.6%	13.0%	9.3%	11.1%	2.28	1.352	**Disagree**
	24.1%	40.7%	11.1%	9.3%	14.8%	2.5	1.356	**Disagree**

5. In my company, accident investigation results are always shared among all workers. **6.** In my company, recommended actions in accidents investigation reports are always taken place after accident.	29.6%	31.5%	18.5%	11.1%	9.3%	2.39	1.280	**Disagree**
Accidents_reporting_system						**2.38**	**0.640**	**Disagree**

**DS= Strongly Disagree, D=Disagree, N A/D= Neither Agree nor Disagree, A= Agree, SA= Strongly Agree, M=Mean and SD=Standard Deviation.*