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The Effectiveness of Non-regulated HSE Cases in the Drilling Industry

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by

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1 Abstract

Background and Purpose

The safety case regime, as a control measure to major accident hazard, was introduced to the oil and gas industry, three decades ago, following the Piper Alpha disaster. It appeared that safety cases had not passed the cost-benefit analysis, and its effectiveness had not been ascertained. This study investigated the effectiveness of non-regulated safety cases, within one of the oil and gas drilling companies, by determining its level of utilisation and examining its impact on the risks of major accidents and other rig incidents.

Method

The study design was cross sectional, retrospective and experimental. A questionnaire was administered electronically, after it had been tested and its validity and reliability had been assured, to five rig supervisors of 10 rigs that owned safety cases. Incidents were extracted from the company incident logs. The risk of major accidents and other rig incidents were compared and analysed before and after the introduction of safety cases, and against a control group.

Results

Out of 50 rig supervisors, 42 (84%) completed the questionnaire. The majority of the respondents indicated that they did not perceive a rig safety case as the most effective tool in reducing major accident risks; however, they agreed that safety cases were still required. Moreover, the introduction of safety cases to six rigs did not reduce the risk of major accidents or other rig incidents.

Discussion and Conclusions

The level of utilisation of non-regulated safety cases was evaluated to be below average. Furthermore, the evidence showed that safety cases did not reduce the risk of incidents. Conversely, the majority of the respondents indicated that safety cases were still needed in the drilling industry. The aim and objectives of the study were achieved; four hypotheses were tested, and recommendations were put forward for the company management and future researchers.

2 Acknowledgements

This fine work would not have been possible without the support of several individuals.

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4 Abbreviations

Acronym	Definition
ALARP	As Low As is Reasonably Practicable
ANOVA	Analysis of Variance
CBA	Cost-Benefit Analysis
CE	Chief Electrician
CEO	Chief Executive Officer
CIMAH	Control of Industrial Major Accident Hazards
CM	Chief Mechanic
COMAH	Control of Major Accident Hazards
COO	Chief Operating Officer
e-mail	Electronic Mail
ERP	Emergency Response Procedure
F	Frequency
HAZID	Hazard Identification
HSE	Health, Safety and Environment
HSE	Health and Safety Executive
HSEO	HSE Officer
HSES	HSE Supervisor
IADC	International Association of Drilling Contractors
IMS	Integrated Management System
ISO	International Organization for Standardization
JSA	Job Safety Analysis
LDU	Land Drilling Units
M	Mean
MODU	Mobile Offshore Drilling Unit
MOPO	Matrix of Permitted Operations
NIOSH	National Institute for Occupational Safety and Health
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NTP	Night Tool Pusher
OHSAS	Occupational Health and Safety Assessment Series

Acronym	Definition
OIM	Offshore Installation Manager
OMF	Operations Manager Offshore
OMN	Operations Manager Onshore
p	Probability
PIC	Person in Charge
QHSE	Quality, Health, Safety and Environment
RM	Rig Manager
RS	Rig Superintendent
SD	Standard Deviation
SMS	Safety Management System
SPSS	Statistical Package for Social Sciences
UK	United Kingdoms
USA	United States of America

5 Introduction

5.1 Background

A safety case is a control measure that aims at reducing major accident risk. The safety case regime was introduced to the oil and gas offshore industry, in the United Kingdoms (UK), following the Piper Alpha tragedy in 1988. The Piper Alpha disaster was one of several offshore major accidents that resulted in hundreds of fatalities and damages worth of billions of pounds. As a result of the Piper Alpha major accident, all the UK offshore duty holders had to examine their installations and processes, develop set of documents (safety cases) which demonstrate that risks of major accidents have been reduced to a level that is as low as is reasonably practicable (ALARP), and submit the safety cases to the regulator for evaluation and approval (Oil & Gas UK, 2008).

The safety case concept continued to grow and root in other industries and countries. Shortly after the introduction of the safety case regulation in the UK, other sectors, such as the chemical and railways industries, started adopting the concept (Inge, 2007). Moreover, other countries, such as Norway and Australia, replicated the safety case concept while other countries, such as Qatar and Malaysia, recommended the model as best practice. Furthermore, throughout the years, safety cases encompassed health and environmental aspects, and became Health, Safety and Environmental (HSE) cases (International Association of drilling contractors, 2018).

5.2 Non-regulated Safety Cases

Safety cases may not be taken seriously in the absence of a regulator. One of the pillars of a successful safety case regime is the presence of a powerful regulator who can challenge, scrutinise, judge and even reject the content of a safety case (Wilkinson, 2002); however, when a safety case is not regulated, the burden falls on the drilling contractors to self-regulate the safety cases that they had developed. In the author’s experience, it is not uncommon for drilling contractors to be financially oriented; hence, it is not unusual for a non-regulated safety case to be developed in a manner that is least expensive, disruptive and hectic since the primary goal is to check the box that a rig has a safety case in place. This means that a non-regulated safety case may contain inaccurate details, insufficient information and incomplete chapters without being picked up or challenged by anyone. Furthermore, while some client oil companies take great interest in a rig safety case, in the author's experience, it is not unusual for an oil company to accept a rig safety case without reading the complete safety case document which may be more than 600 pages. To put simply, a safety case without a strong regulator, who oversees the safety case regime, may become a useless document without anyone noticing or pushing back.

5.3 Effectiveness of Safety Cases

The effectiveness of safety cases in reducing major accident risk may not have been yet proven. It appears that the effectiveness of non-regulated safety cases in the drilling industry has not yet been covered in any of the existing literature. Although safety cases were designed to prevent major accidents, there seems to be an agreement that due to the rare occurrence of major accidents, it is difficult to establish a sound connection that safety cases have achieved what they were meant to do (Fenning & Boath, 2006; Hopkins, 2014). Moreover, in the author's experience, nowadays, the process of putting together a safety case document entails copying bits and pieces from the drilling contractor's safety management system; hence, it might be possible to argue that neither the document nor the process adds much value to the workforce of the rig or the overall reduction of HSE risks.

5.4 Cost of Safety Cases

The cost of a safety case may be unjustifiable. There seems to be an agreement that completing a cost-benefit analysis for a safety case is difficult if not impossible. While the process of developing a safety case for one rig, in the author's experience, may cost over one hundred thousand pounds, it might not be possible to quantify the gains of rare events that might not even take place (European Commission, 2011; Hopkins, 2014). Accordingly, it might be difficult to explain the rationale behind the sacrifices that go into developing a safety case.

5.5 The Reason for Conducting This Study

In short, in line with what has been discussed so far, while the safety case concept keeps on progressing, a non-regulated safety case may be considered a costly and ineffective control measure that may not be a credible best practice. This research examines the level of utilisation of rig HSE cases by the rig personnel to determine the importance of HSE cases to those on the shop floor. Also, the study investigates the effectiveness of HSE cases in reducing incidents and major accidents on onshore and offshore drilling rigs. Eventually, an evidential argument will be presented on the contemporary effectiveness of non-regulated HSE cases in the drilling industry. The outcome of this study may provide sufficient evidence that non-regulated safety cases might not be the best investment for drilling contractors.

5.6 The Research Problem

What is the contemporary effectiveness of non-regulated HSE cases in the drilling industry?

The Setting

5.7 The Country of Operation

The research was conducted at one of the national drilling companies in the Middle East. The country of operation recommends safety cases as a best practice; however, safety cases are not nationally regulated or enforced. While the drilling contractor has no rigs operating outside the home country, other international drilling contractors work in the same region.

5.8 The Drilling Contractor

The national drilling company was established in 2004 as a partnership between the national oil producer and a foreign drilling contractor. In 2008 all the company shares were bought by the national oil producer, and the company became 100% nationally owned. The drilling contractor provides onshore & offshore drilling services to national and international oil producers (client oil companies). Currently, the company operates a fleet of 20 assets: nine offshore jack-up rigs, five land drilling rigs, three land work-over rigs, two lift boats and one accommodation jack-up. Furthermore, the company owns a central warehouse which provides parts and consumables to the rigs; central workshop which accommodates major rig repairs and overhauls; five water-well drilling rigs which support the land rigs, and the main camp that accommodates the onshore rig personnel. Additionally, the drilling contractor operates under an Integrated Management System (IMS): the system is International Organization for Standardization (ISO) 9001:2008, ISO 14001:2004 and Occupational Health and Safety Assessment Series (OHSAS) 18001:2007 certified (Ali, 2017).

5.9 Drilling and Working Over a Well

Drilling a well starts with moving a rig to a given location by a client oil company. This is followed by drilling the top hole to the desired depth; then, the hole is cased and cemented to prevent the hole from caving in; then, smaller drilling bits are used to drill the next sections until the oil or gas reservoir is reached. From there, usually, client oil companies work with their service providers to prepare the well for production. On the other hand, work-over rigs do not generally drill new formation, but they mostly maintain a well/hole to start, sustain or restart production (Anon, 2017b).

5.10 Client Oil Companies

Different client oil companies have different standards and HSE tools. While some client oil companies require a safety case, others demand a comprehensive competency program or an HSE plan. The client requirements are usually stipulated in the contractual agreement which is signed by the drilling contractor’s Chief Executive Officer (CEO). To ensure that the conditions are complied with, the client oil company typically perform a pre-acceptance/pre-spud thorough inspection. If an HSE case is one of the contractual requirements, a part of the acceptance inspection would typically, in the author’s experience, be checking that the HSE case has been developed and in place; however, when a new HSE case is required, typically, client oil company representatives are invited to attend the hazard identification (HAZID) workshop of the HSE case and they would normally be aware of the progress and the status of the HSE case.

5.11 Workforce and Working Patterns

The drilling contractor has a workforce of around 1600 employees. Approximately 200 employees work at the head office while the rest work at rig sites. The rig staff are permanent employees and do not change from well to another. The rig staff are mostly males, expatriates and in good health. The rig staff's level of education diverges from those who can barely read and write to those who carry postgraduate qualifications. Senior rig staff work on four weeks on/off rotation while the junior rig staff work for a more extended period: eight weeks onshore and six weeks offshore (Ali, 2016). Rigs operate around the clock on 12-hour shifts. The number of company employees on each rig depends on the type of rig: on a work-over rig, the number of on-duty workers is around 45; on a drilling rig, approximately 65, and on an offshore rig, about 85. In addition to the rig crew, rigs accommodate client oil company's representatives and many service providers who perform various well-supporting activities. Occasionally, rigs receive visitors; nonetheless, visits require management authorisation, records of mandatory training and governmental passes (Anon, 2017a).

Each rig has two assigned HSE Officers (HSEO); each HSEO works on four weeks on/off rotation. The HSEO works on days, without coverage during the night shift. Rig HSEOs report directly to the Person in Charge (PIC) of the rig. Onshore, the PIC is the Rig Superintendent (RS) while offshore, the PIC is the Offshore Installation Manager (OIM). The HSEO also functionally reports to the office-based HSE Supervisor (HSES). The HSES reports to the Quality, Health, Safety and Environment (QHSE) Manager. Figure 1 below illustrates the HSE organisational chart (Anon, 2015).

5.12 HSE Duties

The rig HSEO provides HSE technical support to the rig management team on compliance with applicable legal, company and client requirements. The HSEO, amongst other duties, is responsible for delivering the HSE in-house training, conducting HSE meetings, inspecting safety equipment, participating in incident investigations and monitoring the rig HSE performance (Anon, 2017a).

5.13 Rig Management Team

The rig management team is often referred to the rig PIC (RS or OIM), the rig night PIC (Night Tool Pusher 'NTP'), HSEO, Chief Mechanic (CM) and Chief Electrician (CE). Rig management teams have access to the rig HSE case document and are responsible for the operationalisation of the rig HSE case on their respective rigs (Anon, 2017a).

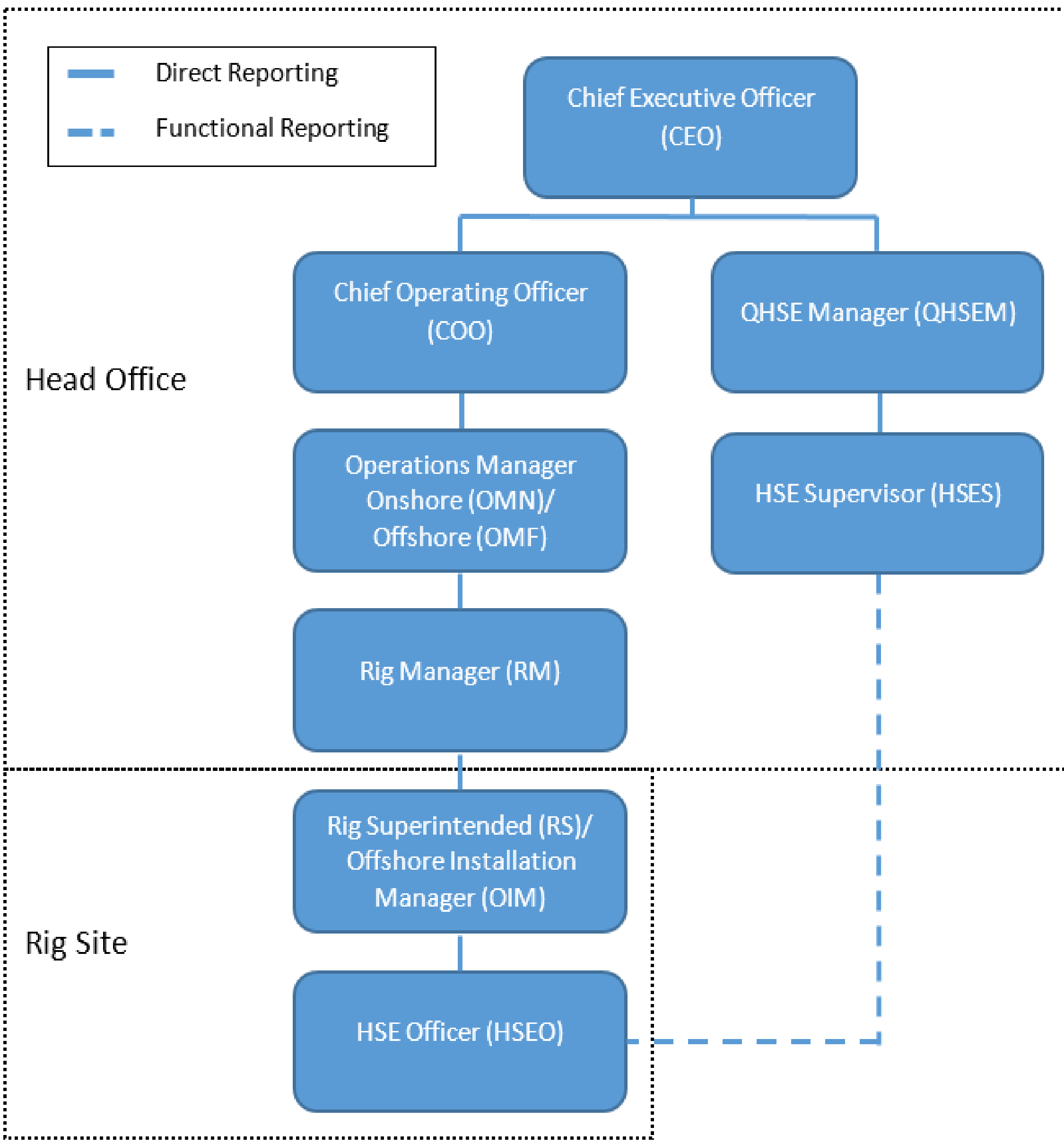


Figure 1 HSE organogram

6 Aim and objectives

6.1 Aim

To investigate the contemporary effectiveness of non-regulated HSE cases in one of the national drilling companies in the Middle East.

6.2 Objectives

1. To determine the level of utilisation of non-regulated safety cases on the day-to-day running of oil and gas rigs.

2. To ascertain the ability of non-regulated safety cases in reducing the risk of major accidents.

3. To examine the effectiveness of non-regulated safety cases in reducing the risk of other rig incidents.

6.3 Hypotheses to be Tested

H1 = Non-regulated HSE Cases are not being utilised, by the rig team, to manage the risks arising from the rig activities.

H2 = Non-regulated HSE Cases do not reduce the risk of major accidents.

H3 = Non-regulated HSE Cases do not reduce the risk of other rig incidents.

H4 = In-line with the above, non-regulated HSE cases, nowadays, may no longer be required.

7 Literature Review

7.1 An Offshore Oil and Gas Installation is one of the World's Riskiest Workplaces

Some industries are more deadly than others. Mining for oil and gas is considered one of the world's most dangerous sectors (International Labour Organization, n.d.). In the United States of America (USA), the National Institute for Occupational Safety and Health (NIOSH) published statistics that showed that the fatality rate of the oil and gas industry is five times higher than the average of all industries (NIOSH, 2002). Similarly, in the UK, in a report that was published 16 years later, the same rate, of fatal injuries, was reported (Health and Safety Executive, 2018). In addition to the oil and gas inherent risks to people, other forms of undesirable outcomes include damages to company properties and spills to the environment (Baram et al., 2013). Moreover, those who work on offshore installations are exposed to additional risks since help may not be promptly provided (Sanger, 2017); this has been supported by the International Organization of Standardization (ISO) who listed 165 hazards that are associated with the operation of offshore petroleum and natural gas installations (ISO, 2016); this list is the most comprehensive list of hazards that the author has seen in his career. This illustrates that an oil and gas offshore installation is one of the world's deadliest workplaces when taking into account the likelihood and the severity of harm accruing due to exposure to the inherent hazards of the industry.

7.2 Major Offshore Oil and Gas Accidents

Similarly, on an offshore oil and gas installation, some hazards and accidents are more deadly than others. Hazards that can cause major accidents are called major hazards (ISO, 2016). According to the International Association of Drilling Contractors (IADC), hydrocarbons in a formation that can result in a blowout; toxic gas that can be released; flammable material that can cause fire or explosion, and helicopter operations that can lead to a crash are some examples of major hazards and major accidents (IADC, 2015). An inclusive definition of major accidents is given in The Offshore Installations (Offshore Safety Directive) (Safety

Case etc.) Regulations (2015:5) which classifies the events below as major accidents:

> (a) an event involving a fire, explosion, loss of well control or the release of a dangerous substance causing, or with a significant potential to cause, death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it;
> (b) an event involving major damage to the structure of the installation or plant affixed to it or any loss in the stability of the installation causing, or with a significant potential to cause, death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it;
> (c) the failure of life support systems for diving operations in connection with the installation, the detachment of a diving bell used for such operations or the trapping of a diver in a diving bell or other subsea chamber used for such operations;
> (d) any other event arising from a work activity involving death or serious personal injury to five or more persons on the installation or engaged in an activity on or in connection with it; or
> (e) any major environmental incident resulting from any event referred to in paragraph (a), (b) or (d).

In the last three decades, 14 major accidents on offshore oil and gas installations killed 788 workers. In November 1979 in China, only four workers, out of 76, survived the 'Bohai 2' oil rig capsize as a result of a storm while being towed; in March 1980 in Norway, 123 workers drowned when the 'Alexander L. Kielland' semi-submersible platform capsized due to rough sea state accompanied with an undetected crack on one of the platform braces; in February 1982 in Canada and in October 1983 in China, no survivors were found following the 'Ocean Ranger' oil rig and the 'Glomar Java Sea' drillship capsize that was caused by strong storms which collected 165 lives; in August 1984 in Brazil, 'Enchova Central' platform suffered a blowout, fire and explosion that killed 42 workers; in July 1988 in the UK, 167 workers were killed in the renowned 'Piper Alpha' disaster; in November 1989 in Thailand, 91 workers were killed when the drillship ‘Seacrest’ capsized by a Typhoon; in March 2001 in Brazil, 11 workers were killed by multiple explosions on semi-submersible oil platform ‘Petrobras' P-36’; in July 2005 in India, 22 workers were killed on the ‘Mumbai High North’ platform as a result of a fire that was caused by a collision with a drifted vessel; in October 2007 in the Gulf of Mexico, 22 workers were killed on the ‘Usumacinta’ jack-up due to a series of events which were initiated by a storm (Verdict Media Limited, 2018); in April 2010 in the Gulf of Mexico, a blowout on the ‘Deepwater Horizon’ killed 11 workers; in December 2011 in Russia, 53 workers drowned when the ‘Kolskaya’ jack-up rig capsized while being towed (Reuters, 2011); in February 2015 in Brazil, five workers were killed by an explosion on one of Petrobras’ rigs; in April 2015 in the Gulf of Mexico, four workers were killed by an explosion on one of the rigs that was being operated by Pemex (Arnold & Itkin LLP, 2018). From this, it can be inferred that major accidents on offshore oil and gas rigs are lethal, and it appears that the deadliest amongst those major accidents was the Piper Alpha disaster.

7.3 The Collen Report

The Piper Alpha tragedy was a wakeup call for the offshore oil and gas industry. The Piper Alpha was one of the largest North Sea oil platforms that was producing oil and gas from a number of wells, and was connected to two other installations and shore base via pipelines. On July 6, 1988, a gas leak ignited and resulted in multiple explosions that killed 167 workers (Oil & Gas UK, 2008). It was also reported that the cost of the accident was around 1.7 billion British Pounds; hence, the Piper Alpha tragedy was not only the world’s most lethal accident but also it is believed to be the costliest human-made accident in history (Lyczkowski, 2018:328). The incident was a game changer to the industry; following the incident, and even before the official investigation report was released, the offshore operators had looked into their installations and processes to assess its robustness, and to ensure that there were enough safeguards to prevent another Piper Alpha disaster (Oil & Gas UK, 2008). After 28 months from the date of the accident, the investigation report, commonly known as ‘The Collen Report’, was published. The investigation report had 106 recommendations. A key recommendation for the Health and Safety Executive (HSE) was to introduce a legislation that requires those managing offshore installations to develop and present a ‘Safety Case’ to the regulator for approval (Cullen, 1990); in turn, the Safety Case regulation came into effect in 1992, and by the end of 1995, all safety cases, of the UK offshore operators, had been accepted (Oil & Gas UK, 2008). The evidence highlights that the safety case regime was introduced, as a new control measure, to the offshore oil and gas industry following the Piper Alpha tragedy as one of the investigation recommendations which was adopted and acted upon, in a relatively short period, by the UK offshore oil and gas industry.

7.4 The History of Safety Cases

Although the term ‘Safety Case’ was new to the oil and gas industry, it was not a new control measure. There seems to be an agreement that the origin of safety cases was from the UK nuclear industry in the 1950s following one of the nuclear incidents (Wilkinson, 2002; Inge, 2007; European Commission, 2011; Baram et al., 2013); however, the requirement for safety cases was only formally introduced in the 1960s through the ‘Nuclear Installations Act 1965’. Afterwards, the safety case regime continued to be adopted by different industries, starting with the offshore oil and gas through the introduction of the ‘The Offshore Installations (Safety Case) Regulations 1992’; followed by the chemical industry through the introduction of the ‘Control of Industrial Major Accident Hazards (CIMAH) Regulations 1994’; and to ‘The Railways industry Railways (Safety Case) Regulations 1994’ (Inge, 2007). It appears that Lord Colin believed that the safety case regime had been successful in the nuclear field that he recommended to introduce it to the offshore oil and gas industry following the Piper Alpha disaster; moreover, it is clear that the concept continued to spread to cover more fields.

7.5 What a Safety Case is

As discussed earlier, a safety case is a control measure aimed at preventing major accidents. One of the definitions of a safety case, according to the Ministry of Defence (2007:17) is:

> A structured argument, supported by a body of evidence that provides a compelling, comprehensible and valid case that a system is safe for a given application in a given operating environment.

Another straightforward definition describes a safety case as a document that outlines all major hazards, potential consequences and controls, and it aims to demonstrate that the operator is capable of managing all major accident risks that are arising from the operator's activities (Health and Safety Executive, 2006). It looks as if there is no universal definition of what a safety case is; however, the two given examples indicate that the safety case is verification that the installation is safe.

There seems to be a number of basic standard requirements for all safety case regimes. Wilkinson (2002:5) discussed that the main feature of a safety case is the demonstration that the risk level has been reduced to a level that is as low as is reasonably practicable (ALARP); this guides duty holders to continue to adapt control measures until any further reduction in risk level is grossly disproportionate to the sacrifices (in terms of efforts, time or money) (Health and Safety Executive, 2001b:63). Wilkinson (2002) also emphasised that safety cases must be developed by the duty holders who have the in-depth knowledge of their operation. Moreover, control measures must take into account both technical and managerial safeguards. Furthermore, the case must contain the expected functionality (performance standards) of the safety critical elements and systems of the installation. Additionally, the workforce must participate in the development of the safety case. Most importantly, a potent regulator must be present. From this, it can be suggested that there are a number of pillars to the safety case regime and that the absence of any of them may affect the integrity of the whole system.

The safety case concept continued to evolve over the years. In the UK in 2005, the Safety Case Regulation was revised, and a new regulation came into force in 2006 (The Offshore Installations (Safety Case) Regulations, 2005). Moreover, safety cases spread to cover the onshore drilling units and encompassed health and environmental aspects, and became known as HSE cases. While the requirement for safety cases is regulated and enforced in some countries such as the UK and Australia, it is considered best practice elsewhere including in the Middle East.

Figure 2 below illustrates where safety cases are required by law and where they have been adopted as best practice (International Association of drilling contractors, 2018). Knowing that the safety case regime was introduced to the UK oil and gas industry around three decades ago, it seems that several oil and gas countries have not adopted the safety case regime which might indicate that the safety case concept did not manage to convince everyone of its importance or effectiveness.

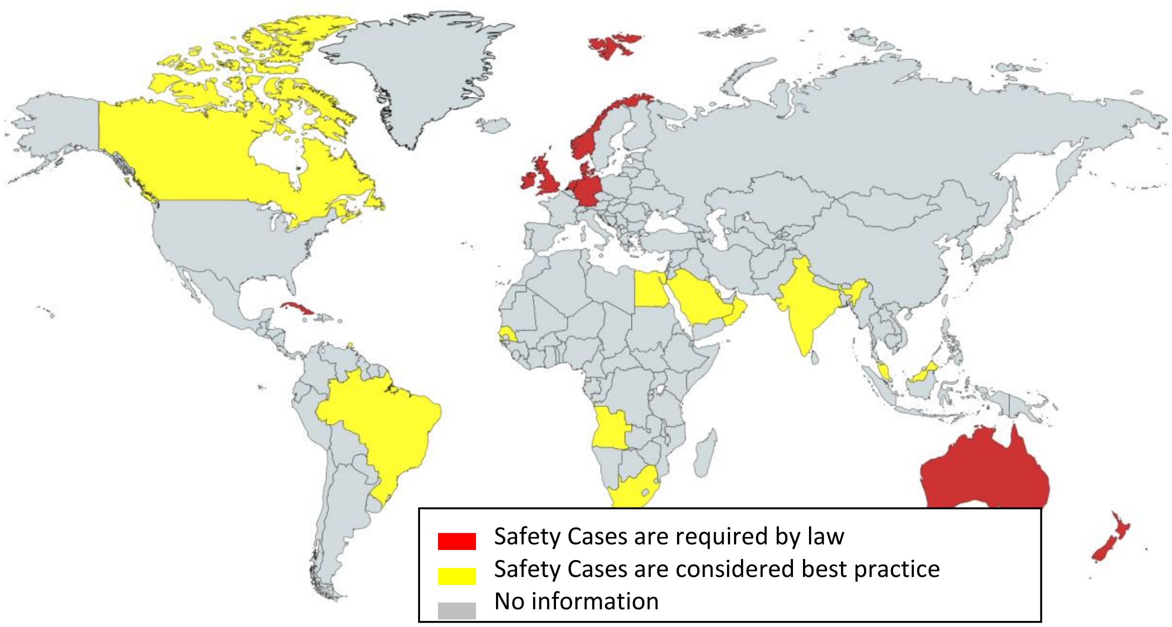


Figure 2 Adoption of safety cases across the world

7.6 The Enforcement Dilemma

The level of enforcement significantly defines the quality of the safety case. As mentioned earlier, in some countries, the safety case regime is regulated where the safety case must be presented to the regulator for review and acceptance before the commencement of the rig operation. For example, this is done by the Health and Safety Executive in the UK (The Offshore Installations (Safety Case) Regulations, 2005), and by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) in Australia (Offshore

Petroleum and Greenhouse Gas Storage (Safety) Regulations, 2009). Hopkins (2012:4) stated that "A safety case is a case - an argument made to the regulator" (emphasis original); whether the *case* is convincing, a regulator may accept or reject the case. He also mentioned that If a case is rejected, duty holders are obliged to resubmit the safety case and endure any losses encountered due to delays in commencing their operations; once the regulator accepts the case, complying with the contents of the case becomes the law, and any nonconformity becomes an offence. As far as it is possible to discern, the stronger the regulator is, the more comprehensive the safety case will be in order to get accepted on time. Logically, duty holders ensure that the content of the safety case is suitable and sufficient as not to incur any uninvited losses. Nonetheless, the situation differs in the absence of a regulator.

Safety cases may be futile in the absence of strict law and a strong enforcer. Where a safety case is not regulated, a duty holder becomes the judge and the defendant too. Where safety cases are not required by law and are developed as a best practice, the operator self-regulates the safety case (Wilkinson, 2002). In such circumstances, the primary focus, in the author's experience, is to check the box by having the safety case prepared regardless of its contents. Conversely, there seems to be an agreement on the importance of the regulator's role in the safety case regime: This was highlighted by Hopkins (2014) who argued that many duty holders only establish a quality hazard analysis and adequate control measures in the presence of a "competent, independent, engaged, well-resourced regulator" (page 12). This corresponds with the view held by Wilkinson (2002) who coupled the success of the safety case regime with having an "independent regulator with adequate legal powers" (page 6). Moreover, in an earlier conference, Hopkins (2012:5) envisaged that a safety case regime is set for failure if not examined by a proficient regulator. Hopkins backed his argument by giving an example of an incident that happened due to having a flawed safety case that had been prepared internally without being scrutinised by an external regulator. Hopkins (2012:6) concluded his argument by stating that, "without scrutiny by an independent regulator, a safety case may not be worth the paper it is written on". The evidence indicates that without a regulator, who judge and scrutinise the safety case, the safety case regime may be pointless.

7.7 Safety Case as a Best Practice

Where safety cases are not legally required, safety cases become an optional administrative control measure. In the author's experience, several oil companies, as a best practice, incorporated a requirement for safety cases in their contracts regardless of their area of operation. Likewise, several drilling contractors, as an initiative, develop safety cases for their rigs to enhance their reputation and the marketability of those rigs. However, other international oil companies do not require safety cases but mandate having a competency program for the drilling contractor's staff. Accordingly, several factors may influence the choice of a safety case, when not required by law, as a risk reduction measure, such as the applicability, benefits, cost and effectiveness of safety cases. In short, other aspects are considered to determine the choice of a safety case as a safety barrier when they are not required by law.

7.8 The Cost Dilemma

One of the primary considerations may be given to the cost of a control measure in comparison to the added value; one of the tools which is widely used for that purpose is the Cost-Benefit Analysis (CBA). CBA is a simple way of comparing the monetary values of the costs and benefits to demonstrate whether the risk reduction measure is viable (Health and Safety Executive, n.d.). While safety cases had been introduced to prevent another Piper Alpha disaster from happening, Hopkins (2014:16) argued that it is "impossible to quantify the benefits of preventing rare but catastrophic events". Although Hopkins based his theory on data obtained from the UK and Norway only, and did not consider other major accident worldwide, major accidents remain rare events (Wilkinson, 2002; Vinnem, 2010). Hopkins argument was backed by the impact assessment that was carried out by the European Commission, following the Deepwater Horizon accident in the Gulf of Mexico in 2010, to evaluate the proposal of introducing a safety case regulation for the offshore industry. The European Commission conclusion was that it was "very difficult to generalize about the economic costs of offshore accidents" (European Commission, 2011:11); the conclusion was attributed to the numerous intangible costs, to major accidents, that cannot have monetary values associated to, such as the effects on oil prices, future of the oil industry, impact on the energy supply, loss of corporate reputation and security of the offshore occupations. On the other hand, in the author's experience, the cost of developing a rig safety case may exceed one hundred thousand pounds, taking into account consultancy fees, costs related to holding the hazard identification (HAZID) workshop and staff working hours. On balance, it appears that the sacrifice that goes into developing a safety case is unjustifiable as there seems to be an agreement that what a safety case is attempting to prevent is rare (might not even happen) and impossible to quantify its impact.

7.9 The Benefits Dilemma

As discussed earlier, safety cases have existed for around 70 years now and continue to evolve. This alone may be considered sufficient evidence of its success (Wilkinson, 2002). Nevertheless, it appears that none of the existing literature has established substantial evidence that safety cases have successfully reduced major accident risks. The European Commission claimed that the introduction of safety cases could halve the number of major accidents (European Commission, 2011); however, that statistic was challenged by Hopkins (2014) due to having a weak basis. Hopkins argument was in line with the research that was conducted, for the Health and Safety Executive, to assess the effectiveness of the UK onshore safety cases which were required as part of the Control of Major Accident Hazards (COMAH) Regulations 1999 where the researchers concluded that they did not find any tangible indications that the introduction of COMAH has caused a reduction in major accident risk (Fenning & Boath, 2006). Furthermore, although it was reported that there had been a substantial reduction in the frequency rate of fatalities and lost time injuries since 1997 (Health and Safety Executive, 1995; Oil & Gas UK, 2008), this is purely a lagging indicator that does not denote how conforming safety critical elements are being managed; hence, leading indicators must be assessed in addition to lagging indicators; when doing so, it appears that, since 1997, the number of helicopter incident's almost remained the same; the number of hydrocarbon releases did not actually drop until 2005 as well as the average number of overdue preventative, corrective and deferred safety critical maintenance (Oil & Gas UK, 2017). As far as it is possible to discern, safety cases are spreading which might indicate that they are beneficial; still, it appears that there is no assertion that they have succeeded in reducing major accident risks.

Safety cases may be most effective during the design stage. When the process of developing a safety case is initiated at the design stage, safety measures and improvements may have a greater opportunity of being discussed and incorporated as engineering control measures rather than relying on administrative controls that count on people. In some situations, some hazards may even be eliminated by design. On the other hand, when the process starts late, safety cases tend to be developed to merely argue that the system is safe. Hence, late start turns safety cases from a proactive control measure to a paper exercise to justify that the system is safe to operate (Leveson, 2011). In the author's experience, most companies start the process of developing a rig safety case after the rig had been built and the crew hired which eradicate the chance of considering the requirement of a safety case at the design stage.

Although the reduction in major accident risk may not have been firmly proven, there may be other advantages to the safety case regime. Some of the perceived gains include better understating of the risks and control measures of the duty holder's installations and processes, greater workforce engagement, demonstrating that the ALARP level has been achieved, communicating performance standards, increased workforce knowledge, and enhancing the duty holder's management systems and internal controls. Nonetheless, all of these alleged benefits have been debated.

Most, if not all, the safety cases were developed by consultants and not by the duty holders themselves. The requirement for the operators to examine their operation, while developing a safety case, improves their understanding of the hazards and risks involved, along with the existing technical and managerial controls required to manage those risks (Wilkinson, 2002). Despite this, the actual work, to put a safety case together, is often done by a consultant and not by the drilling contractor's workforce; hence, the reliance is on a third party to perform quality work that the drilling contractor does not have sufficient competence to complete. Moreover, since safety cases were something new, the number of consultants who were able to do such work was limited, and some of them might have tended to produce non-user-friendly versions to ensure that they would continue to find business (Holland et al., 2010). Similarly, in the author's experience, most of the HSE case consultants, when producing safety cases, are using computer software which a drilling contractor does not have access to, and modifications may need to be routed through the consultant (usually with additional fees). For these reasons, the duty holders' understanding of the risks and risk control measures of their rigs and operations may remain unchanged.

Workforce engagement may be hard to achieve. As discussed earlier, the safety case regime encouraged the involvement of the workforce as they are directly contributing to and affected by the rig safety performance. Wilkinson (2002) suggested that engaging the workforce enables them to think and understand how their actions/inactions can affect the overall safety performance. Wilkinson (2002:10) communicated that, from the perspective of most of those working on hazardous installations, safety cases have been fruitful; however, it appears that he did not provide a reference for this statement. Conversely, based on experience, the workforce is only involved in the HAZID workshops. Furthermore, since rig crews work on rotation, it is inevitable that not everyone will be involved; however, one of the exceptions would be if the rig has not yet started to operate. This means that the returning crew, who had not attended the HAZID discussion, might be required to review and implement what had been discussed and agreed on during the HAZID workshop by their back to back. From this, it can be inferred that although engaging the rig crew in developing the rig safety case may facilitate their buy-in, not all the workforce is typically engaged due to the rig work patterns; hence, continuity in implementing a safety case may not be achieved.

Most of the safety cases are not user friendly. Since the primary target audience of a safety case is the regulators, little consideration is usually paid to provide a troublesome-free document to the workforce (Lamb & Pegram, 2012). However, in the author's experience, some companies take the initiative of providing supplementary documents to present clear information about the rig safety case. Needing supplementary aids to enable understanding implies the level of complexity of a safety case.

Another perceived benefit of safety cases is enhanced risk management. It is not unusual that the process of hazard identification and risk assessment to necessitate additional control measures that would contribute to a safer installation.

Moreover, demonstrating the ALARP requires continual review and improvement to the management systems and controls. Furthermore, having performance standards for safety-critical systems facilitates the auditing and verification process. All of the previously-mentioned factors contributed to enhancing the operator's Safety Management System (SMS), and in some case, new management systems were developed (Wilkinson, 2002:10). Overall, it seems that Wilkinson believed that the safety case regime was not flawed, but was not straightforward to implement. An alternative perspective was given by Haddon-Cave (2009:533) who suggested that the safety case regime has "lost its way … led to a culture of 'paper safety' … [and] It currently does not represent value for money" (emphasis original). Moreover, Hopkins (2014) reasoned that the hazard analysis that exists in a company's management system is similar to the hazard analysis of a safety case; this means that the safety case may not add additional values for the identification of hazards, assessment of risks and determination of adequate control measures. The evidence illustrates that apart from the claimed reduction in major accident risk, it is believed that safety cases have other benefits such as increased knowledge of the risks, improved risk control measures and continual improvement of the safeguards; however, it may be safe to debate that the mentioned benefits are essential components of any safety management system, and they can be achieved without having a safety case. To put simply, it may be safe to assume that without a proper HSE management system, a drilling contractor would be struggling to find a place in the drilling business; hence, all of the discussed perceived benefits of the safety case, and more, may already be in place, and having a safety case may be considered an unnecessary duplication (Ali, 2017).

Maintaining a safety case can be challenging. Assuming that a state of the art safety case has been developed, changes in regulations, designs or safety measures would typically prompt a requirement for the safety case to be reviewed and revised to reflect those changes. While it might not be noticeable, small changes may create ripple effects in a complex document. Moreover, some indirect impacts may be difficult to recognise and might affect the integrity of the argument (Kelly & McDermid, 2001). It might be safe to assume that due to the rig busy operations, a proper safety case review may not be possible at the rig site, and it might be impracticable to arrange for the consultant who developed the safety case to continue to review the safety case now and then. In turn, the rig safety case might become out of date and might act as a dust collector at one of the rig offices.

7.10 Non-Regulated Safety Cases in the Drilling Industry

Drilling rigs' safety cases tend to follow the International Association of Drilling Contractors (IADC) guidelines. IADC has issued guidelines for Mobile Offshore Drilling Units (MODU) and Land Drilling Units (LDU) to aid with harmonising international HSE standards into a single methodology that is custom-made to the drilling industry. As the guidelines conform to all the existing safety case regimes, the IADC HSE case guidelines can be adopted by any rig that is working anywhere (International Association of drilling contractors, 2018). Nonetheless, IADC acknowledged that pursuing an international standardisation of a drilling HSE case has not yet been encouraged due to the different roles and responsibilities of stakeholders in different countries (Hoffmark, 2016). The IADC safety case guidelines consist of six parts: Part-1 is purely an introduction to the HSE case and its requirements. Part-2 describes the elements of the operator's management systems: policies and objectives; organisation, responsibilities, and resources; standards and procedures; performance monitoring, and management review and improvement. Part-3 describes the rig equipment and systems including safety equipment and lifesaving appliances. Part-4 is the central part and contains the hazard register and safety-critical activities, and within which demonstration of the ALARP level is communicated. Part-5 describes the rig contingency procedures. Part-6 describes the performance monitoring arrangements (IADC, 2009; 2015). As a consequence, due to the IADC efforts, the IADC guidelines are being implemented on a global scale.

The components of the HSE case already exist in the company management system. It could be argued that a safety case does not introduce anything new to a company with a well-developed management system: Part-2 summarises the company's HSE manuals. Part-3 lists the rig equipment which is part of the rig asset register. Part-4 is a smaller version of the company risk register. Moreover, the demonstration of the ALARP might not even be required by law. Part-5 is a reflection of the rig emergency response plan. Part-6 is, again, copied from the company HSE manuals to communicate the monitoring procedures (ISO, 2015; The British Standards Institution, 2018). As discussed earlier, it seems that an HSE case does not add much value, if any, to a company with a comprehensive management system which is what major drilling contractors have.

8 Methodology

8.1 Study Design Description

The effectiveness of HSE cases is a concept that cannot be measured. What is meant by 'effectiveness' can be perceived differently; hence, it is essential to convert the effectiveness, as a concept, to variables that can be measured. A variable is defined as a concept that can be measured. This conversion, from a concept to a variable, can be done directly, or through converting the concept to indicators and then variables (Kumar, 2014). For this study, the latter method was utilised in order to demonstrate a logical progression.

To measure the effectiveness of HSE cases, three indicators and three variables have been chosen. The three indicators were the degree of utilisation of a rig HSE case, reduction in the risk of major accidents, and reduction in the risk of other rig incidents. The three variables were the level of utilisation of the rig HSE case, the number of major accidents and the number of other rig incidents. Figure 3 below illustrates the conversion process (Ali, 2017).

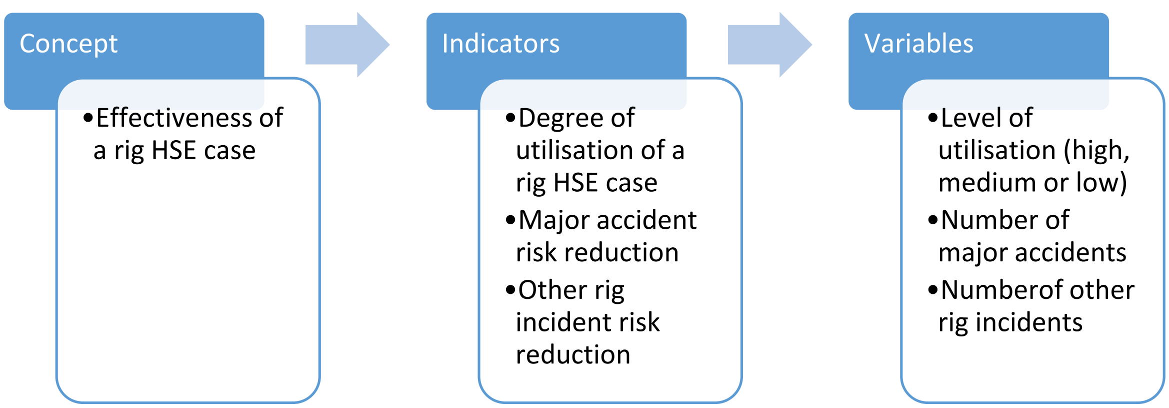


Figure 3 Measuring the effectiveness of HSE cases

The research had five types of variables: Independent, dependent, intervening, chance and extraneous variables. An Independent variable is the reason that is supposed to be bringing about a change in a situation. As the study examined the effectiveness of HSE cases, the independent variable was the availability of a rig HSE case. The dependent variable is the change that takes place following the introduction of the independent variable. As HSE cases were designed to prevent another Piper Alpha disaster, the main dependent variable was the potential reduction in major accident risk. Additionally, since major accidents, as communicated previously, are rare events, the study took other rig incidents into account. An intervening variable links the cause (independent variable) and effect (dependent variable); in this study, this was the level of utilisation of the rig HSE case. While collecting research data, changes in the dependent variable attributed to respondents' attitudes or misunderstandings related to the research instrument are called chance variables. In this study, chance variables were disregarded as they often equalise and cancel each other (Kumar, 2014:128). The last type of variables was the extraneous variable.

The effects of an extraneous variable cannot be eliminated; however, it can be controlled and minimised by the introduction of a control group. Rigs' HSE cultures, standards that had been set by oil client companies, commitments of rig management teams and other similar factors are considered extraneous variables. An extraneous variable may influence the effect of the independent variable on the dependent variable. As the study was conducted in a real working environment and not in a laboratory, the researcher had no control over extraneous variables. Moreover, the elimination of extraneous variables was not possible due to the different aspects that are affecting each rig. Furthermore, due to the limited resources, it was not possible to incorporate extraneous variables in the study. Nonetheless, to ensure that the independent variable had the maximum chance to affect the dependent variable, an attempt was made to control extraneous variables through the introduction of a control group. The function of a control group is to quantify the effects of extraneous variables. In this study, the control group was a number of rigs that do not have safety cases; however, they, too, were being affected by similar extraneous variables. Figure 4 below elucidate the research variables (Ali, 2017).

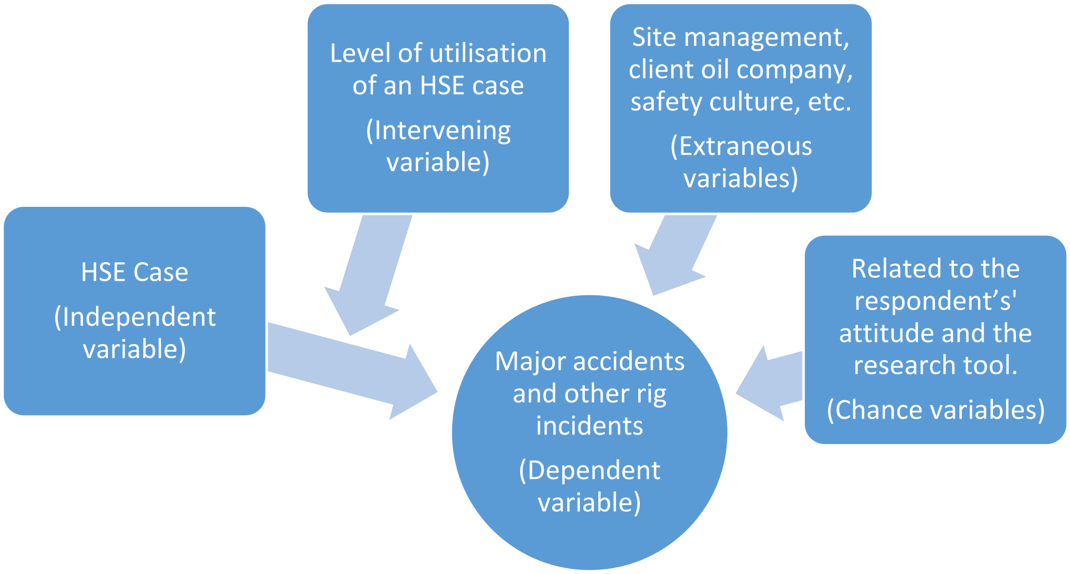


Figure 4 The research variables

The qualitative-quantitative-qualitative study design was considered to be the best approach to evaluate the effectiveness of HSE cases. The qualitative part of the research instrument provided qualitative data on the level of the operationalisation and utilisation of rig HSE cases. This part enabled exploring the extent of the variation with regards to the importance of HSE cases. The quantitative aspect of the research instrument and incident statistics provided quantitative data on the potential reduction in major and other rig incidents. This side facilitated the quantification of the variation that had been quantitatively described. Eventually, the outcome of the study was discussed qualitatively (Kumar, 2014:133-134). Figure 5 below illustrates the described approach (Ali, 2017).

Figure 5 The qualitative-quantitative-qualitative approach

8.2 Type of Study Design

The classification of the study design can be approached from three routes: the number of contacts, reference period and nature of the investigation. From the first perspective, as the research instrument was only administered once to the sample population, the study can be considered a 'cross-sectional' study. Although cross-sectional studies do not measure change over time, they facilitate obtaining an overall understanding of the subject being studied at the time of the study. Next, from the 'reference period' perspective, the study can be classified as 'retrospective' since the study examines the effectiveness of HSE cases in reducing major accidents and other rig incidents that had already taken place. Finally, since the study started with the cause (being the availability of an HSE case) to determine the effect (being the potential risk reduction of major accident and other rig incidents) in normal work environment, from the perspective of 'nature of investigation', the study can be categorised as natural, experimental study (Kumar, 2014:134-143). Figure 6 below illustrates the types of study designs (Ali, 2017).

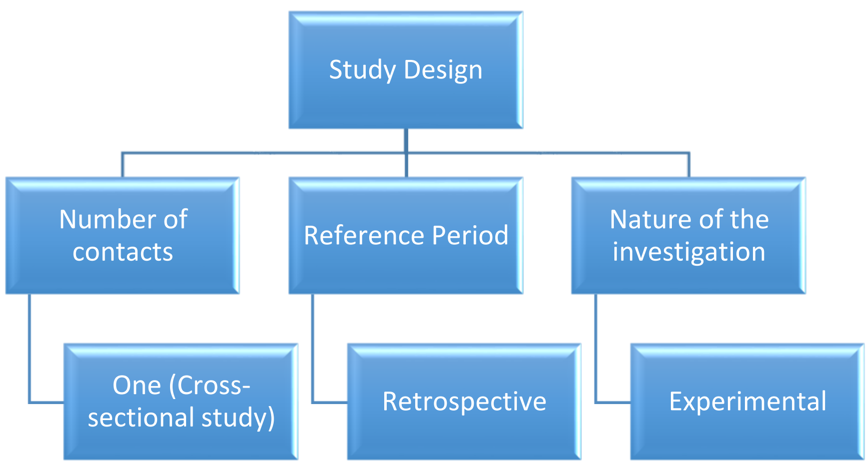


Figure 6 Types of study design

8.3 Data Collection Methods

To examine the effectiveness of non-regulated HSE cases, data was collected from two sources: primary and secondary. Primary sources provide first-hand data while secondary sources provide information that has been collected previously. Secondary data are extracted from existing records that were put together for other purposes, such as routine record keeping while primary data is information that has been obtained from a participant for the specific purpose of the study (Walliman, 2011).

Both primary and secondary sources can provide qualitative and quantitative data. Qualitative data helps in exploring the diversity of the phenomenon being studies while quantitative data quantifies the degree of diversity in the phenomenon (Kumar, 2014). It is alleged that, in some studies, a holistic picture may only be achieved by having a collection of qualitative and quantitative data (Matthews & Ross, 2010). To explain the effectiveness of the HSE case and quantify its magnitude, a mix of qualitative and quantitative data were collected and analysed.

8.4 Primary Data Collection

There are three methods for collecting primary data: observations, interviews and questionnaires. The selection of the optimum method(s) for collecting primary data is influenced by the aim of the research, availability of resources, the competence of the researcher and the "socioeconomic-demographical characteristics of the study population" (Kumar, 2014:173). Observation involves an intentional witnessing of an event as it happens. Interviewing is a way of collecting data from participants for a specific purpose. A questionnaire is a set of written questions that are answered by respondents. One of the main differences between an interview and a questionnaire is that an answer is recorded by a researcher in the former and by a respondent in the latter. Each of the methods has varied strengths and weaknesses that influence the decision of selecting the optimum method.

8.5 Use of a Questionnaire for Collecting Primary Data

To investigate the effectiveness of HSE cases, the most appropriate method for collecting primary data was considered to be through the use of a questionnaire. It is believed that questionnaires are the most commonly used instruments in cross-sectional studies (Matthews & Ross, 2010). Since the respondents were spread out over different rigs that were working at different areas, the use of a questionnaire was evaluated to be the most effective and least expensive way of collecting primary data.

Questionnaires are beneficial, yet challenging. As mentioned above, questionnaires can be used, at almost no cost, to provide answers from respondents who are scattered demographically. Moreover, questionnaires provide anonymity and encourage respondents to provide honest answers without being afraid of being reprimanded. On the other hand, one of the common challenges with the use of questionnaires is low response rates; Kumar (2014) communicated that obtaining a 50% response rate may be considered fortunate. Furthermore, the absence of human interface hinders respondents from being able to clarify ambiguities or seek further details for better understanding. Additionally, the characteristics of a target audience may limit the application of questionnaires. Besides, respondents may only opt to respond if the study subject is of interest. Also, a respondent's answer to questions may be influenced by other people or survey questions (Kumar, 2014).

The questionnaire was developed via 'SurveyMonkey'. 'SurveyMonkey' is one of the most reputable survey websites. Although the website is less useful for resurveying participants, it is valuable for one-off surveys (Gilliam, 2018). Copy of the questionnaire is enclosed at appendix-A.

8.6 Overcoming the Questionnaire Challenges

Measures were taken to attempt to overcome the above-mentioned potential challenges of questionnaires. To overcome the potential low response rate, follow up contacts with the rig personnel were established to encourage and remind them to complete the questionnaire. The author's contact details were enclosed to the questionnaire to enable respondents to clarify any ambiguities. Concerns regarding the limitation in the application of questionnaires had no grounds as responses were sought from the rig supervisors. To eliminate/reduce the possibility of responses being influenced by a response to other questions, the questionnaire was designed to present only one question at a time; moreover, the questions were listed in random order to influence the respondents to demonstrate their agreement and disagreement without conditioning their views. To reduce the power gap between the researcher (office supervisor) and the respondents (field employees), it was assured that the responses would be anonymous. Moreover, the questionnaire was written in a way that was simple, unambiguous, not double barrelled, not based on assumptions, and well organised to capture the respondents' attention. Another important consideration was to construct the questionnaire to be concise to avoid consuming a long time to suit the rig staff's busy operation. Furthermore, the questionnaire was accompanied by a cover letter that gave an impression to respondents that someone was talking to them and communicating the importance and relevance of the research (Kumar, 2014:181-191).

The questionnaire contained open and close-ended questions. Open-ended questions enable participants to respond freely, provide in-depth details, share unconditioned answers and eliminate the chance of researcher bias. On the other hand, open-ended questions pose a challenge for respondents who are not fluent in the language used, usually consume more time to respond to and are more difficult to analyse. Closed questions are more straightforward for respondents to answer, provide factual data and are easier to analyse; however, closed questions may condition the respondents' choices, introduce researcher's bias, switch the questionnaire to tick and flick exercise, and provide responses that lack depth (Kumar, 2014). Having a mix of open-ended and closed questions enabled high-quality information to be obtained.

There are several methods for administering a questionnaire. Questionnaires can be sent to respondents in different ways such as posting, personally delivering, collectively administering or electronically mailing (e-mail) the questionnaire (Kumar, 2014). The latter technique was evaluated to be the most practical means since the questionnaire was created through one of the recognised internet-based survey websites. Link to the questionnaire was administered to respondents directly to their work e-mail addresses.

8.7 Study Population

There are different types of sampling strategies. The three main categories are random, non-random and mixed sampling designs. Random sampling entails selecting a representative sample where the findings can be generalised to the study population. Non-random sampling does not rely on probabilities/generalisation and is used when the population size is unknown or cannot be individually identified. Mixed sampling is, as the name implies, a mix of random and non-random techniques (Kumar, 2014). Since the number of operators who use HSE cases is unknown, the non-random sampling technique was deemed to be the most appropriate.

There are six non-random sampling techniques. Quota sampling involves the selection of a convenient location at which a researcher selects individuals with specific characteristics to be part of the sample population. Accidental sampling is similar to the quota sampling technique, but without being guided by specific characteristics. Convenience sampling is similar to the accidental sampling approach but with additional conveniences to the researcher. Judgemental sampling is a method in which researchers use their judgement to decide who is willing to participate in the study and have the required knowledge of the study subject. Expert sampling is similar to the judgmental sampling technique while the respondents are subject-matter experts. Lastly, snowball sampling is similar to the judgemental sampling method with the respondents being asked to nominate other potential participants (Kumar, 2014).

To determine the effectiveness of HSE cases, the judgemental sampling technique was utilised. Since only a few rig personnel were able to provide information-rich insights on the effectiveness of HSE cases, the judgemental sampling was selected. It is believed that the judgemental sampling technique is beneficial when a study attempts to "construct a historical reality, describe a phenomenon or develop something about which only a little is known" (Kumar, 2014:244). Although judgemental sampling method reduces resource wastages, it is subject to a researcher's bias (Laerd dissertation, 2012b). Bias was avoided by selecting the same positions from each rig; hence, making 'judgemental sampling' the optimum method.

When using judgemental sampling, the aim is to have a predetermined sample size that provides the most accurate results. Having a known number of participants is one of the characteristics that differentiate between quantitative and qualitative researches. The difference is underpinned by the nature of the different research types as in qualitative studies; the aim is to reach the data saturation point which is the point at which participants add a negligible amount of new information. On the other hand, the sample size in quantitative researches is a compromise between resources and the reliability of the results (Kumar, 2014).

The sample population consisted of 50 participants. As discusses earlier, 10 rigs owned HSE cases. From each of those rigs, only key personnel were contacted to be part of the study. Those key personnel were the onshore Rig Superintendents (RS) or Offshore Installation Managers (OIM), Night Tool Pushers (NTP), HSE Officers (HSEO), Chief Mechanics (CM), and Chief Electricians (CE); hence, the study was designed to a sampling frame of 50 information-rich respondents (Ali, 2017). The respondents were all literate males with access to computers and work e-mails.

8.8 Test Population

Before administering the questionnaire to the sample population, it had been pre-tested. Pre-testing a questionnaire enables the identification of potential issues that respondents may face when attempting to understand and answer a questionnaire. Pre-testing a questionnaire involves sending the questionnaire to a test population to evaluate whether the questions are worded correctly, communicate the intended meaning and are similarly interpreted by different respondents (Kumar, 2014:191). Since the purpose of testing a questionnaire is not to collect data but to identify any issues with how the questionnaire was worded, a test questionnaire was sent to the author's colleagues from previous companies. The first feedback from the test population was positive; however, some questions were not as clear as the author perceived. The feedback that was received was utilised to enhance the quality of the questionnaire to function as intended.

8.9 Secondary Data

Secondary data was extracted from the company incident register. The company incident register lists and describes all rigs' reported events throughout the years. The company defined an incident as an event that caused or had the potential to cause harm of any kind, such as injuries to people, damage to equipment or spill to the environment; this term covered both accidents and near misses. As mentioned earlier, the log was filtered to capture the major events and other rig events. Secondary data, which was extracted from company records, was in numerical (incident statistics) and descriptive forms (event description). To examine the effectiveness of HSE cases, incident statistics were examined before and after an HSE case was introduced and after some years of having an HSE case (Ali, 2017).

As covered earlier, to quantify and evaluate the extraneous variables, the incident statistics of a control group formed part of the study. The incident records of four offshore rigs that did not have HSE cases were analysed. To ensure a fair comparison, two of the control rigs have been working for the national oil company while the other two have been working for international oil companies in the national drilling company's country of operation. The selection was based on the consideration of comparing like for a like by attempting to quantify, amongst other factors, the influence an oil company has on the risk of major accidents and other rig incidents.

To examine the effectiveness of HSE cases in reducing the risk of incident, including major accident, the rig incident statistics were examined. For six onshore rigs, the incident logs were analysed for the two years before and after the rig HSE case had been developed. Since the HSE cases of all the onshore rigs were developed in late 2015, the rigs' incident records from 2014 to 2017 were explored. For the two onshore rigs that owned HSE cases since start-up, the incident logs of two years in operation were examined. Similarly, the incident records, from 2014 to 2017, of the two offshore rigs, that had HSE cases for a number of years, were inspected. Moreover, the incident logs were checked for four offshore rigs which acted as a control group. Figure 7 below summarises the periods during which the rig incident records were examined.

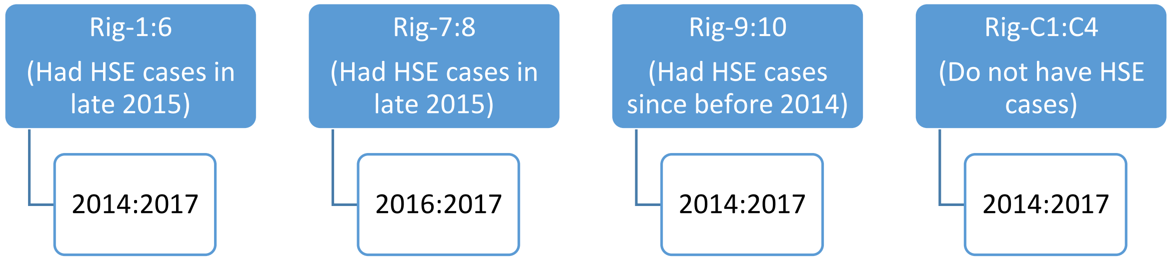


Figure 7 Periods during which the rig incident records were examined

The magnitude/implication of each incident was taken into account. Since only counting the number of incidents did not differentiate between a first aid case and a fatality, a system was developed to assign an actual and potential severity for each incident; this is summarised in Table 1 below. An actual severity is the actual damage that took place due to an incident while a potential severity is the reasonably foreseeable damages that an incident had the potential to cause had the situation been slightly different (Anon, 2018). Each incident was assigned an actual severity and potential severity. One of the weaknesses of the matrix below is that it does not assign a severity based on the number of individuals who were harmed or could have been harmed; the author tolerated this deficiency as although it might be easy to calculate a severity for incidents that caused harm, it was not simple for near nits; hence, the matrix below only provides a framework to quantify the magnitude of the individual incidents for making rational comparisons.

The severity matrix below assigns weights based on the incident classification. A first aid case is any treatment of minor injuries. The IADC provided a list of scenarios based on which an incident may be classified as a first aid case (IADC, 2017:9). A medical treatment case is a work-related injury or illness that necessitates treatment beyond first aid; however, following treatment, injured persons must be able to return to work and carry out their regular duties unrestricted; otherwise, the incident is classified as a restricted work case. A restricted work case, as the classification when a worker is unable to execute all the routine tasks and work on a retracted capacity, such as being assigned to light duties or not performing all routine activities for the whole shift. A lost time incident is a work-related event that results in an employee being given time away from work by a physician or licensed health care professional; the matrix assigns different values based on the amount of medical leave given. A fatality must be work related to be recordable (Anon, 2015). According to the IADC (2019:13), an event is work-related when,

> an event or exposure in the work environment is the discernible cause or contributes to an injury or illness or significantly aggravates a preexisting injury or illness. The work environment includes the

establishment and other locations where one or more employees are working or are present as a condition of their employment. (*sic*)

Lastly, near hits were not assigned an actual severity rating; however, they were assigned a potential severity value that was subjectively evaluated by the author based on his decade of experience in the field of HSE.

Table 1 Incidents actual and potential severity matrix

Classification	Actual Severity	Potential Severity	Classification	Actual Severity	Potential Severity
First Aid Case	1	Calculated by considering the potential of an incident with a slight, realistic, change in the circumstances.	Near Hit	0	1
Medical Treatment Case	3			0	3
Restricted Work Case	5			0	5
Lost Time Incident (LTI < 6 months off)	7			0	7
Lost Time Incident (LTI > 6 months off)	15		Serious Near Hit (High Potential Incident)	0	15
Fatality	30			0	30

Several actions were taken to overcome the challenges that accompanied the data that had been collected from secondary sources. First of all, to eliminate/reduce personal bias, the definition of major accidents, as quoted earlier, was used to calculate the number of major accidents of each rig. Also, the IADC incident definitions were used to categorise and assign actual and potential severities to each incident (IADC, 2017). Moreover, the availability of data was assured by having the approval of the company management team to use the company data in the research. Furthermore, confidentiality of the information was ascertained by using a pseudonym instead of the actual rig names. Additionally, the issues related to the format of date was overcome by going through the incident register line by line to extract the needed data for the research (Kumar, 2014:197).

8.10 Validity and Reliability

To assure the quality of the research findings, the concepts of validity and reliability were taken into account. The check that the data being gathered is what needs to be collected is referred to as ‘validity’ (McNeill & Chapman, 2005:9) while ‘reliability’ is the check that the same results can be obtained by reapplying the research methodology (Matthews & Ross, 2010:11). The application of the concepts differs in qualitative and quantitative research. Moreover, the concepts are influenced by several factors such as the way questions are worded, the respondent’s mood while completing the questionnaire and whether the questions relate to tangible or less tangible matters that are open to different interpretations (Kumar, 2014:213-214).

The validity of the research instrument was verified utilising the face and content technique. Although there are different methods to apply the concept of validity in quantitative research, the ‘face and content validity’ was considered the most appropriate. ‘Face validity’ was achieved in the questionnaire by validating that each question was linked to one, or more, of the research objectives (Kumar, 2014:214), and also by evaluating that each question was able to produce the required answer (Matthews & Ross, 2010:216). On the other hand, ‘content validity’ was established by verifying that questions cover all aspects related to the effectiveness of an HSE case. Although this technique was simple and easy to apply, establishing relations, between questions and objectives/answers, was subjective and could not be quantified (Laerd dissertation, 2012a).

The reliability of the questionnaire was determined by using internal and external consistency procedures. External consistency procedures compare two separate data gathering processes to verify the reliability of the research instrument. To examine the external consistency of the questionnaire, the ‘parallel forms of the same test’ was utilised; this was done by developing two questionnaires and administering them to the test population. Although the technique provided a quick means of examining the external consistency of the questionnaire, it was more challenging and time consuming to devise an additional questionnaire that attempted to have the same aspects measured (Kumar, 2014:217). On the other hand, internal consistency procedures verify that questions, which were formulated to measure the same aspect, generate similar answers regardless of their number (Kumar, 2014:218). Consideration was given to the use of different internal consistency methods; however, none was deemed appropriate: The questionnaire had open-ended questions and was measuring various aspects related to the effectiveness of HSE cases; hence, the ‘split-half technique’ was not suitable. The questions had multiple choices; accordingly, the ‘Kuder-Richardson Test’ was inappropriate. The number of questions and sample population was limited; therefore, the ‘Cronbach's Alpha Test’ was inapplicable (Shuttleworth, 2009). Nonetheless, the internal consistency of the questionnaire was informally examined by comparing the answer and verifying that they are in agreement (Andale, 2016).

The validity and reliability of the qualitative data were also taken into consideration. Although it is believed that the concepts of validity and reliability cannot be strictly applied due to the freedom that is given to respondents to express their thoughts, the trustworthiness and authenticity of the qualitative data were assured by examining four main aspects: credibility, transferability, dependability and confirmability of the results. ‘Credibility’ examined the degree to which the respondents agreed with the outcome of the study. ‘Confirmability’ assessed the degree to which the research result could be ascertained by others. ‘Transferability’ judged the degree to which the research conclusion represented the study population. ‘Dependability’ appraised the degree to which similar results could be obtained from multiple observations to the same study subject (Kumar, 2014:219). It was suggested that integrating the validity and reliability concepts for the quantitative and qualitative aspects of the study assures that the way the research outcome was reached had been precise and appropriate (Kumar, 2014).

8.11 Data Analysis

Data processing involved several procedures. Data which was obtained from the questionnaire and incident logs was a mix of qualitative and quantitative raw data (Matthews & Ross, 2010:456). For a valid conclusion to be drawn, the research hypotheses to be tested and the research objectives to be achieved, that raw data needed to be analysed before being presented. The data processing procedure involved data editing, coding and analysing (Kumar, 2014:294).

The first step in data processing was data editing. Data editing entailed scrutinising the raw data and ensuring that it was free of discrepancies and incompleteness. While data editing can be achieved by examining the answers to one question at a time or by examining the whole response to the questionnaire, the latter technique was adopted to have a better overview of the response. Moreover, during the data editing process, while inconsistencies can be minimised by inferring the answer of one question from another, recalling a respondent's answer and contacting the respondent, only the first option was viable due to the use of an anonymous questionnaire (Kumar, 2014:296).

The next step, following cleaning the data, was data coding. Data coding is the process of converting the data to numbers. The purpose of data coding is to facilitate the data analysis process. Data coding can be done manually or using a computer. Data coding in quantitative studies consists of four stages: The process starts with developing a codebook; then, testing the same to identify any problems; next, coding the data; finally, verifying the coded data to identify any problems with the coding procedure. Although the four stages apply to answers in quantitative and categorical forms, descriptive data undergo a content analysis process before being coded. During the content analysis process, the descriptive data is examined to identify the emerging themes. What has been discussed so far addresses the coding process based on the classification of a response; the other consideration is the way an author intends to present the results which is influenced by the target audience and an attempt to present the technical data while maintaining the readership's interest (Kumar, 2014:296-310). For this study, data coding was completed automatically by the survey website.

After cleaning and coding the data, the final step in the data processing is data analysis. Data analysis involved developing a frame of analysis that described the variables to be analysed along with the type of analysis for each variable. In addition to the variables that were integrated in the questionnaire, the three main variables were, as discussed earlier, the availability of the HSE case which was measured on the nominal scale; the level of utilisation of the HSE case which was measured on the ordinal scale; the number of major accidents and all rig accidents which were measured on the ratio scale. While it was straightforward to interpret the data when presented in tables and charts, an attempt was made to use statistical procedures to establish the strength of the relationships (Kumar, 2014).

Various means were used to analyse and discuss the collected data. Since the number of samples was small, Microsoft Excel figures were used to discuss the observed trends. Moreover, for the six onshore rigs that had HSE cases developed for them in late 2015, a paired t-test was carried out to compare the number of major accidents and other incidents before and after the introduction of an HSE case. A paired t-test is a statistical procedure that compares two means from the same object. The null hypothesis was proposed to be that HSE cases do not reduce the number of major accident and other incidents. The probability (p) was considered to be 0.05. The test assists in accepting or rejecting the null hypothesis based on the value of ‘p’: if ‘p’ is more than 0.05, the null hypothesis is accepted and retained, and it is rejected if ‘p’ is less than 0.05. The test outcome was written showing the mean (M), standard deviation (SD) and frequency (F) (The Minitab Blog, 2016).

To attempt to investigate the potential relationship between the level of utilisation of a rig HSE case and the number of major accident and other rig incidents, a statistical procedure was used. While the level of utilisation was categorised, on the ordinal scale as low, medium and high, and the number of major accidents and other incidents on the ratio scale, a one-way analysis of variance ‘one-way ANOVA’ technique was utilised. This method is useful in determining if there are any statistically significant differences between an independent group, which was the level of utilisation of the HSE case, and a dependent group, which was the number of major accidents and incidents (The Doctoral Journey, 2013). One-way ANOVA was applied on the last two-year incident data for all the rigs that had HSE cases.

For the two offshore rigs that had HSE cases for several years, the incident records were compared with the control group. In addition to the use of Microsoft Excel charts, an independent t-test was conducted. An independent t-test is another statistical procedure that compares between two independent groups on the same variable. Independent t-tests were carried out to compare the mean data of the control group and the offshore rig that was working for either the national oil company or an international oil company (University of British Columbia, 2014). Figure 8 above summarises the statistical procedures which were utilised in this study (Ali, 2017).

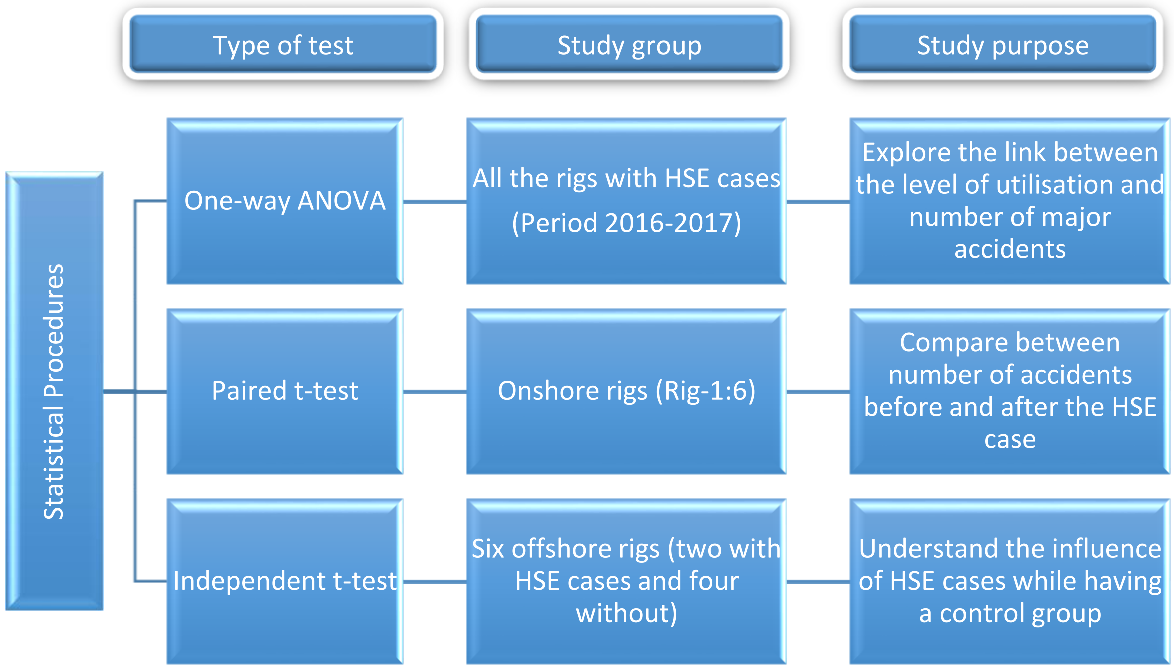


Figure 8 Statistical Procedures

The Statistical Package for Social Sciences (SPSS) was utilised to carry out the statistical tests. The paired t-test, one-way ANOVA and independent t-test were executed using SPSS. SPSS is a software platform that enables superior statistical analyses while maintaining a relatively simple usage (International Business Machines, n.d.). Although SPSS is expensive and its default graphics have relatively low quality, SPSS is easy to use and allows exporting data from different software platforms, such as Microsoft Excel (Warner, 2018).

8.12 Ethical Issues

Ethical issues that were affecting the research stakeholders had been taken into account. The considerations were predominantly related to the research data and outcome (McNeill & Chapman, 2005:100). There are three primary stakeholders in most researches: research participants, the researcher and the funding body. The research stakeholders encompass not only those who participate in the study but also cover those who are indirectly involved in the research and affected by the study outcome (Kumar, 2014:282-284). In this study, those directly involved were the rig supervisors who completed the questionnaire while those indirectly involved, and affected by the research result, were the rig personnel, the drilling contractor's managers, client oil companies, drilling contractor's community and consultants who put HSE cases together (Ali, 2017). Moreover, since the research was self-funded and prepared for the University of Hull, the University represented the funding body.

There were numerous ethical considerations related to research participants. Firstly, to establish the researcher's right to collect information from the participant, approvals were obtained from the company management team. Secondly, to ensure that the respondents' valuable time is not wasted, the questionnaire was designed to be completed in less than 10 minutes. Thirdly, respondents' informed consent was a condition for the respondents to express before being allowed to be directed to the questionnaire. Informed consent confirms that the participants understand the type of information that is sought, the reason for seeking such information and how their participation may impact them. Moreover, the request to participate explicitly communicated that participation was voluntary and participants were not pressured to take part in the study. Furthermore, concerns related to incentives had no grounds as none was offered. Additionally, the questionnaire did not request any sensitive information and only contained business-related queries (Kumar, 2014:284-286). Lastly, to prevent any damages to the reputation of the drilling contractor, the confidentiality of the organisation and anonymity of the respondents were maintained in line with the University guidelines (University of Hull, 2018b).

Likewise, several ethical issues, related to the researcher, were considered. First of all, to maintain the integrity of the study, and to the best of the author's ability, bias was avoided by reporting honestly without signifying or hiding any findings. Additionally, in consultation with the research supervisors, the appropriate research methodology had been selected to draw a valid and reliable conclusion. The selected methodology warranted that the sample population was neutral and not biased; the questionnaire, as the research tool, was valid and reliable, and the research outcome was accurate. Furthermore, care was taken to prevent any inappropriate use of information that might harm the organisation or the participants (Kumar, 2014:286-288). This was achieved by securing the data in line with the University guidelines (Hull, 2018).

Similarly, ethical issues related to the University of Hull, as the authority requesting the research, was assured. The University did not dictate any restrictions on how the research was to be conducted or communicated. Potential restrictions could have been dictating a specific methodology, modifying the study result or opting not to publish the study outcome (Kumar, 2014:288). In addition, the university had a data protection policy that prevents the misuse of information (University of Hull, 2018a).

Besides the ethical issues, while gathering primary data, there are other issues that have been taken into account while collecting secondary data. All borrowed data was cited and referenced to avoid plagiarism, any legal consequences or unethical practices. Moreover, as mentioned earlier, collecting data from secondary sources has been approved by the company operations management team. Furthermore, data was interpreted and categorised in line with the major accident definition, and incident actual and potential matrix. Additionally, pseudonyms were used to assure the confidentiality and anonymity of the rigs and participants (Kumar, 2014:289).

8.13 Research Limitation

The research has several limitations. The limitations mainly revolve around the resources that had been allocated to the study and the data that was accessible to the researcher. Some of the main limitations are discussed below.

Lagging indicators were used to determine the effectiveness of HSE cases. The effectiveness of HSE cases was evaluated using lagging indicators: the number of major accidents and other rig incidents whereas incorporating leading indicators such as safety-critical safety maintenance could have strengthened the argument. Additionally, there might have been other factors that affected the incident trends over the years, such as, amongst others, the company's improved safety culture which might have promoted transparent and more honest reporting, changes the management system and incident definitions, changes in personnel, and alteration in the recruitment process. Moreover, incident severities did not take into account the number of people affected as it was difficult to estimate the impact of major accidents as covered earlier.

The number of elements in the sample population could have been larger. The questionnaire was sent to 50 rig supervisors when it could have been sent to all rig personnel. Although increasing the number of respondents would have increased the credibility and representation of the outcome, the aim of the study was to investigate and understand the effectiveness of non-regulated HSE cases, and hence, less emphasis was given to ensuring that the findings are representative (Kumar, 2014).

The study was based on data that had been acquired from only one company. The safety culture of a company plays a vital role in operationalising its safety programs, including HSE cases. It would have been beneficial to compare the data obtained from the national drilling contractor with other companies that had the same risk factors; however, access to incident logs of other companies is usually restricted and confidential.

9 Results and Discussion

9.1 Overview

To examine the effectiveness of HSE cases in the drilling industry, a questionnaire was sent to 10 rigs that owned HSE cases. The questionnaire was designed to facilitate the understanding of the level of importance, utilisation and effectiveness of a rig HSE case. The questionnaire was created on ‘SurveyMonkey’, and the link to the survey was electronically mailed to the sample population. The questionnaire consisted of 15 questions. The questions were a mix of open and close-ended questions. The sample population consisted of 50 rig supervisors; out of which 48 accessed the survey; however, it was only completed by 42; hence, the completion percentage was 84% which demonstrated a high participation rate (Kumar, 2014:181). The average time spent on completing the survey was calculated, by the survey website, to be 12 minutes and 14 seconds which was 20% over the planned/expected duration.

9.2 Feedback

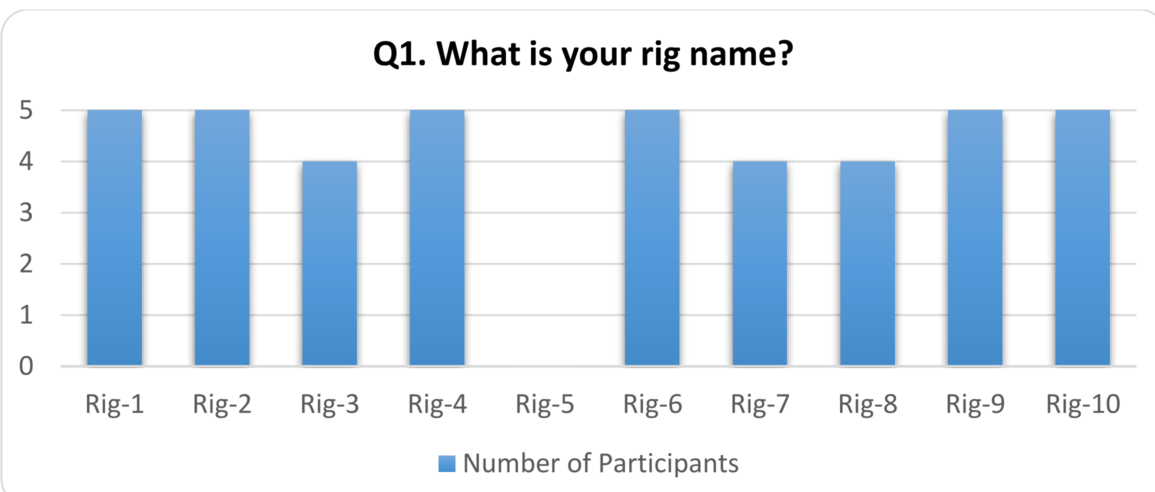


Figure 9 Participation by Rig

The first question in the questionnaire asked respondents to select their rig. Out of the 10 rigs, six rigs participated fully; four out of five supervisors participated from three rigs, and one rig did not participate at all. Figure 9 above summarises the level of participation by rig; however, the question had the actual names of the rigs and not the pseudonyms that are shown in the above figure. It was essential to identify the respondent’s rig to correlate the level of utilisation of the HSE case with the incident rate of the particular rig. It is highly likely that asking the participants about their rig name was the reason for the six persons, who entered the survey and did not complete it, to decide not to take part in the survey (Falkowitz & Herrera, 2015).

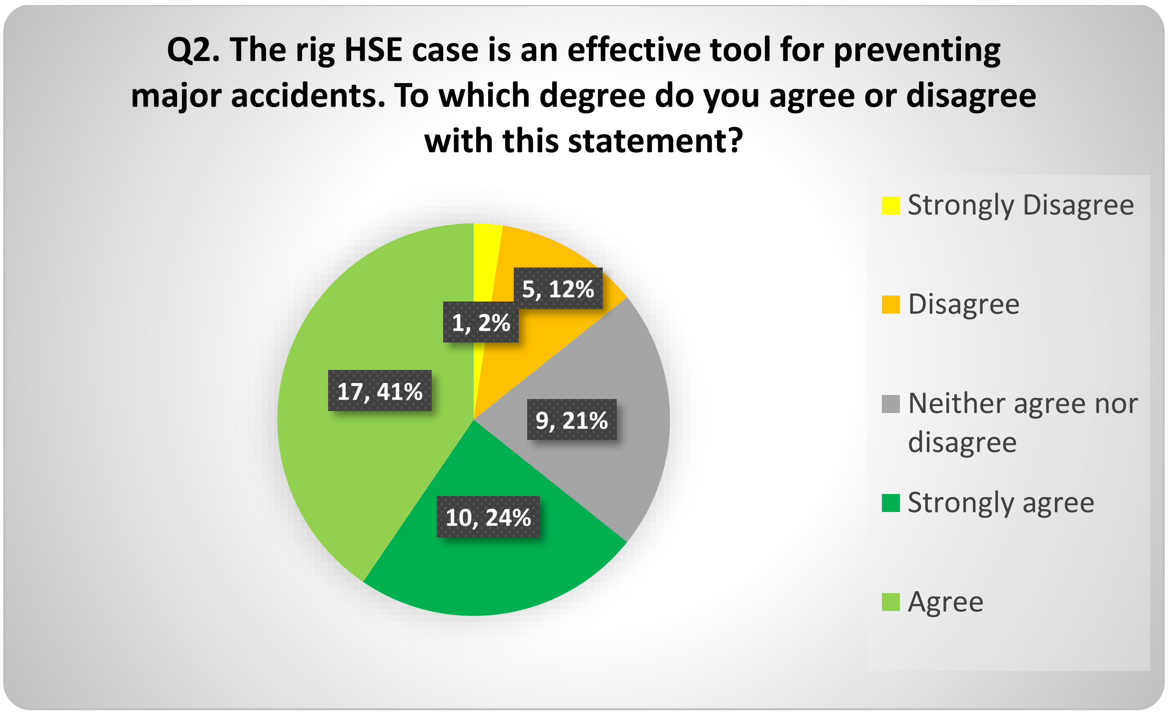


Figure 10 HSE case effectiveness in preventing major accidents

The second question asked the respondents to indicate their level of agreement or disagreement with whether the rig HSE case is an effective tool for preventing major accidents, and the third question asked the respondents to back up their response. Overall, it seemed that the majority (65%) perceived that a rig HSE case was effective. 10 (24%) respondents strongly agreed; 17 (41%) agreed; nine (21%) neither agreed nor disagreed; five (12%) disagreed, and one (2%) strongly disagreed. Figure 10 above provides a snapshot of the respondents’ feedback.

Out of the 42 participants, 26 opted to support their selection, on the effectiveness of HSE cases in preventing major accidents, with more details. Those who agreed that the HSE case is an effective tool highlighted that rig HSE cases contained rig specific hazards and controls, lessons learnt from previous accidents, responsibilities assigned to individuals to prevent major accidents, relevant instructions for all personnel, and sufficient reference material to ensure that activities were carried out safely. Conversely, those who disagreed mentioned hurdles such as unfamiliarity with the HSE case, difficulties in communicating and understanding the HSE case at different levels, having suffered a major accident despite of having an HSE case in place, the infrequent use of the rig HSE case, the impracticality of reading hundreds of pages while managing the rig at the same time, and the struggles in having the HSE case implemented. Although most, if not all, of the perceived benefits and drawbacks of an HSE case had already been covered earlier, the majority considered the rig HSE case an effective tool for preventing major accidents.

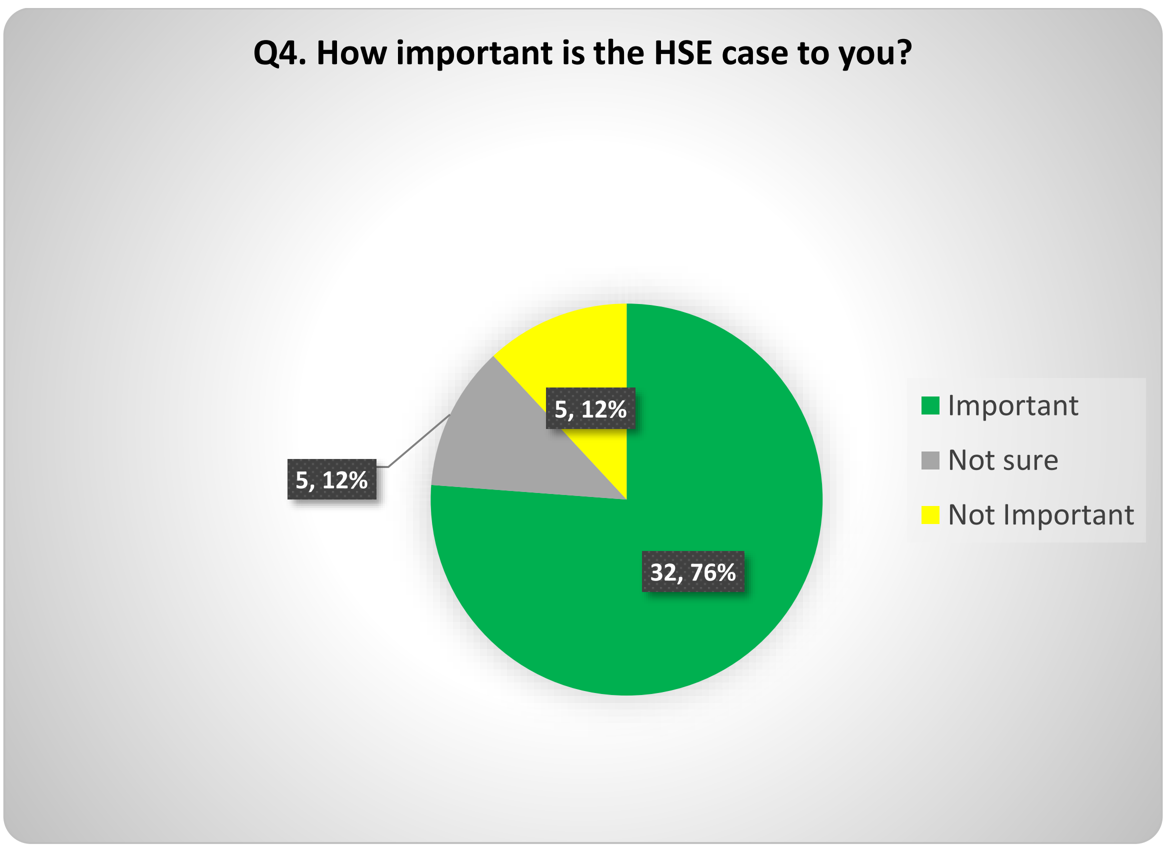


Figure 11 Level of Importance of the rig HSE case to respondents

The fourth question asked the respondents to express how important the rig HSE case is to them. Likewise, the responses showed that the majority of the respondents indicated that the HSE case was important. That was shown by 32

(76%) participants answering that it was important while five (12%) answered that they were unsure, and five (12%) mentioned that it was not important. Figure 11 above provides a summary of the responses to the level of importance of the rig HSE case from the participant's perspectives. The question attempted to stimulate a response on the overall importance of the HSE case which is not only related to incident prevention.

The fifth question asked the respondents to express how effectively the rig HSE case was supervised and enforced. Out of the 42 participants, 30 provided reasons for their selection. The answers to this question varied between rig to rig and even within the same rig; however, it appeared that approximately 45% of the participants believed that it was sufficiently supervised. Those who realised that the HSE case was adequately supervised and enforced provided positive feedback that the rig HSE case was continually enforced by the rig management and the company top management. On the other hand, those who felt otherwise mentioned that the rig supervisors do not have sufficient understanding of the HSE case to enforce it. There were also comments implying that the level of supervision was dependent on who of the rig supervisors was on shift. Moreover, one of the comments from Rig-3 was that the level of supervision, of the HSE case, increased intensely after the fire accident which the rig had in 2016. Despite being an open question, and although the answers were not to the level of details as expected, it seemed that those who perceived that the HSE case was not being adequately enforced gave more practical details to support their answers while those who thought that the level of enforcement was adequate merely mentioned that it was being driven by management. It might be possible to argue that the responses to this question were not representative as they directly related to a rig management team's performance in enforcing and implementing one of the company programs.

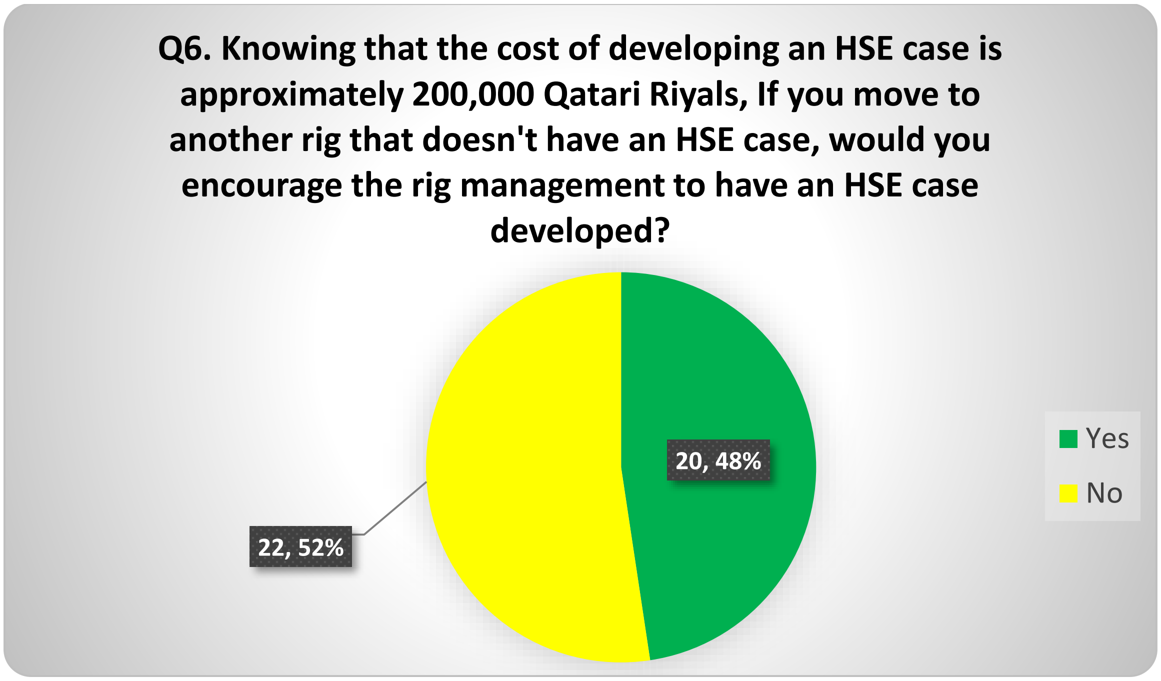


Figure 12 An HSE case versus its cost

The sixth question asked the respondents to identify whether they would encourage the rig management to have an HSE case developed if they move to another rig that did not have an HSE case. The majority of the replies were negative: 22 (52%) participants mentioned that they would not encourage management to have an HSE case developed while 20 (48%) supported the initiative. Figure 12 above represents the respondents' feedback.

There seemed to be a contradiction between the answer to this question and the previous ones. Despite the answers to the previous questions which signified the effectiveness and importance of HSE cases, the greater part of the sample population implied that the sacrifice in having an HSE case developed overweigh the benefits. In the previous question, 32 respondents stated that a rig HSE case is important to them; however, only 20 thought that an HSE case should be developed when not in place. One of the possible explanations might be that rigs were mandated to use HSE cases without consultation; however, when the rig crew becomes involved in the decision-making process, their perception and level of involvement differ (Health and Safety Executive, 2001a:7).

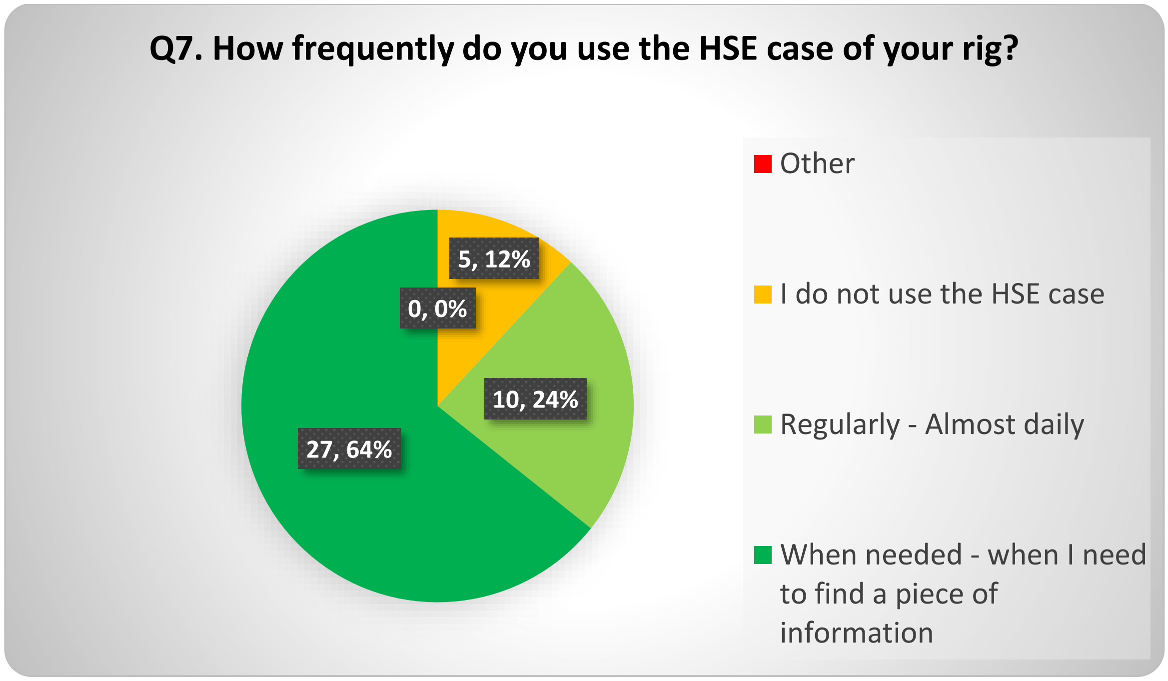


Figure 13 The frequency of using the rig HSE case

The seventh question inquired about the frequency of using rig HSE cases. Most respondents stated that they only refer to the rig HSE case when needed to find out the required information; this answer was given 27 (64%) times. Regular, an almost daily, reference to the rig HSE case was selected 10 (24%) times while five (12%) respondents communicated that they do not use the rig HSE case. Figure 13 above shows a breakdown of the responses.

A rig HSE case document is readily available to all rig supervisors. The feedback to this question was as predicted since rig HSE cases are stored on the rig shared folder/drive and readily accessible to all supervisors. Having an electronic copy of an HSE case assists in navigating and searching the document to find the sought information (Wilkinson, 2002). In short, since HSE cases contain tons of information, and they are available, in electronic format, to the rig team, they form a good reference when a piece of information is sought. The outcome of this question assisted in establishing the first objective of this study which was to determine the level of use of rig HSE cases in the daily management of the rigs.

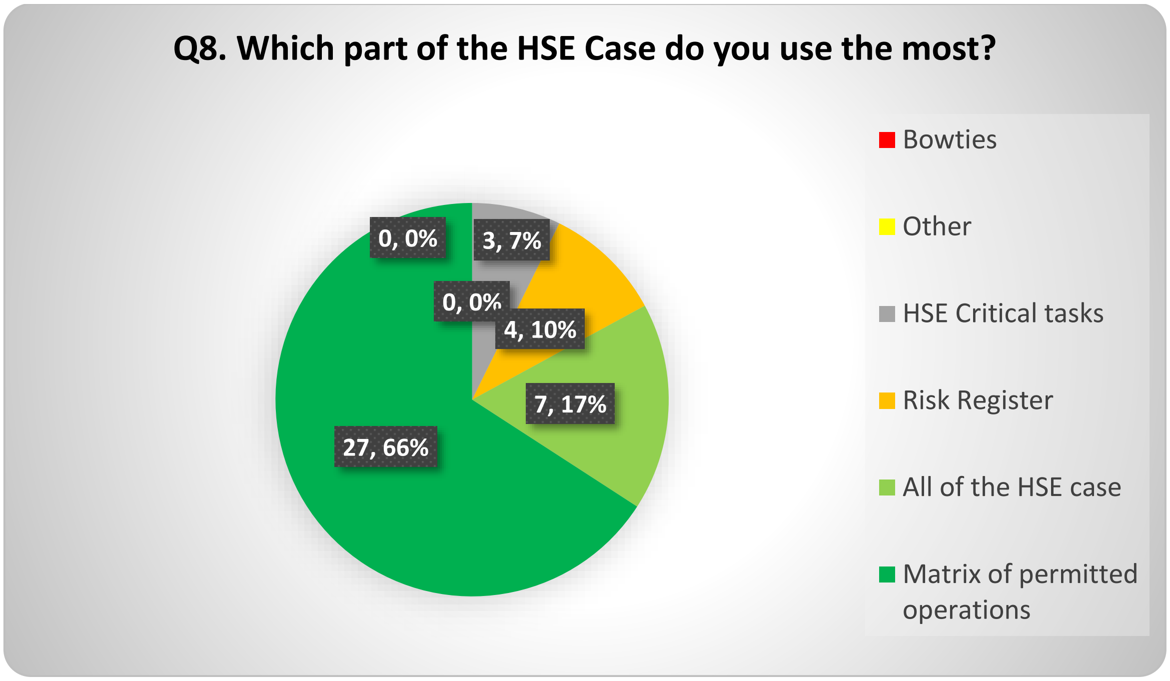


Figure 14 The Part of the HSE case that is being used the most

The eighth question investigated which part of the HSE case that participants use the most. The majority of the respondents answered that the matrix of permitted operation (MOPO) was the most used section of the HSE case; this response was given 27 (66%) times. Seven (17%) respondents stated that they use the whole HSE case while four (10%) mentioned that it was the risk register, and three (7%) specified that it was the HSE critical tasks that were being utilised the most. Figure 14 above presents the responses regarding the part of the HSE case that was being used the most.

The MOPO was identified to be the most frequently used tool. In the author's experience, many factors might have resulted in such feedback. First of all, there were great emphases from the company management that the MOPO must be used in planning every task. Secondly, the construction of the MOPO takes place in the HSE case hazard identification (HAZID) workshop where the attendees put their heads together to think of all the possible conflicting tasks and consequences. Moreover, every rig manager printed out the MOPO chart for their respective rigs, and they were posted in various locations around the rig. It is believed that this evidence justifies the selection of the MOPO as the most used part of the HSE case. It might be safe to argue that certain parts of the HSE case cannot be used, such as the part 1 (introduction to the HSE case), part 2 (description of the company safety management system) and part 3 (description of the rig equipment); hence, claiming the utilisation of the whole HSE case might be questionable.

The question was designed to assist in understating the part of the HSE case which was being utilised the most. The answers aided in fulfilling the first objective of this study.

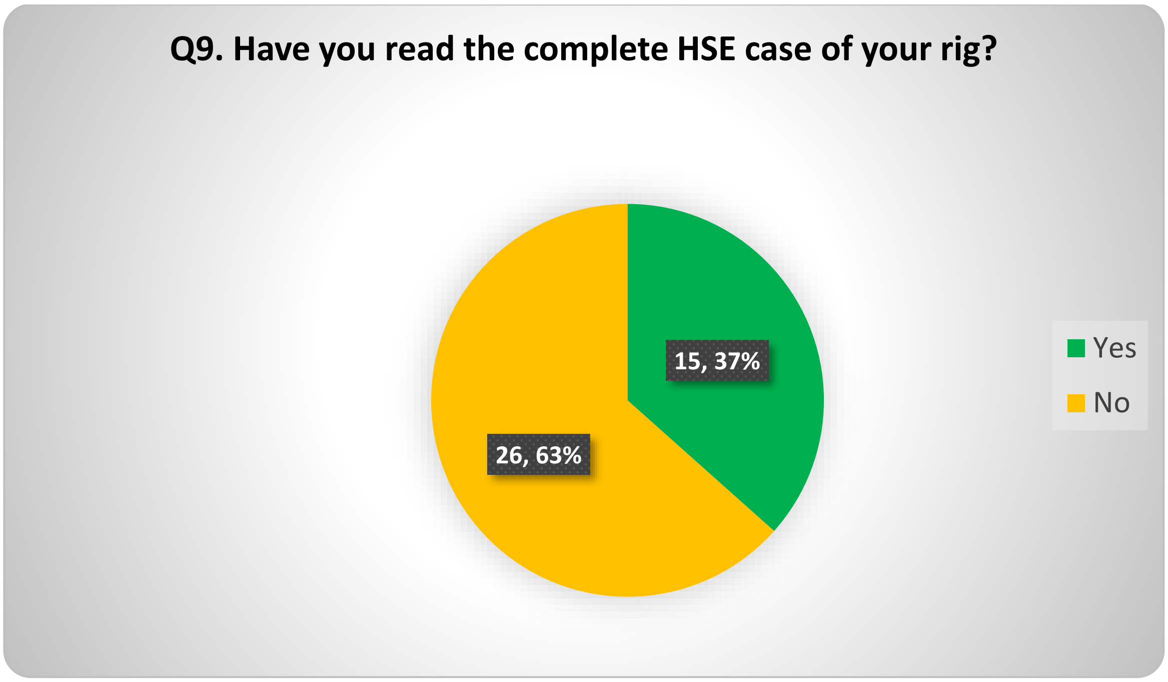


Figure 15 Whether the respondents have read the complete rig HSE case document.

The ninth question asked the respondents to indicate whether they had read the complete HSE case of their rig. The majority indicated that they had not read the complete HSE document; there were 26 (63%) responses indicating the same while 15 (37%) respondents mentioned that they had read it in full. Figure 15 above gives an overview of the responses.

Respondents' comments on other questions justified the feedback on this question. There was repeated mention of the level of complexity of an HSE case coupled with the rig supervisors' limited time to go through hundreds of pages. This had already been identified by Wilkinson (2002) who envisaged that the more detailed the HSE case is, the more pages to be read and the less beneficial the document becomes to the company's own staff. Another common reason was the unbalanced level of literacy of the rig crew versus the way an HSE case was written. Consequently, two-thirds of the respondents declared that they had not read the complete rig HSE case document, and accordingly, they might not have been familiar with the full requirements/details. Similarly, this finding contributed to satisfying the first objective of this research.

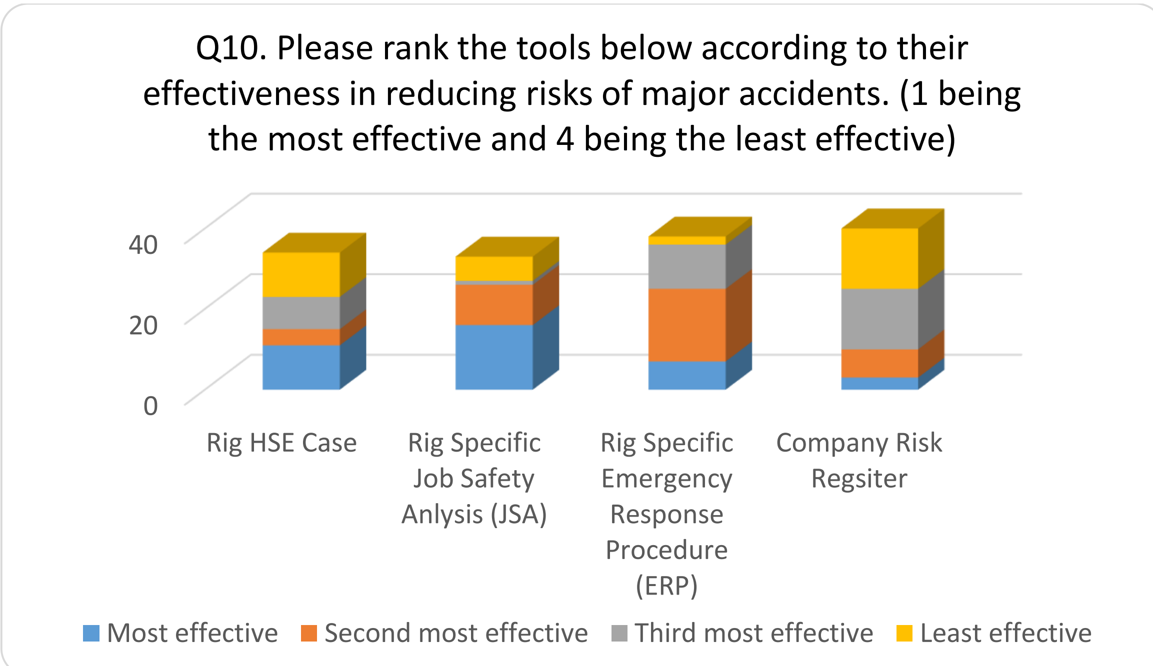


Figure 16 Effectiveness of different tools in reducing risks of major accidents

The tenth question invited the respondents to rank some of the common tools, including the rig HSE case, that were being used at the rig to reduce risks of major accidents. The most effective tool was determined to be the job safety analysis, followed by the rig emergency response procedure and lastly, the company risk register. While choosing the most effective tool, 16 (48%) respondents selected the rig specific job safety analysis (JSA); 11 (32%) picked the rig HSE case; seven (18%) chose the rig specific emergency response procedure, and three (8%) opted for the company risk register. While selecting the second most effective tool, 18 (47.4%) respondents identified it to be the rig specific emergency response procedures; 10 (30.3%) elected the rig specific job safety analysis; seven (17.5%) chose the company risk register, and four (11.7%) picked the rig HSE case. While deciding the third most effective tool, 15 (37.5%) selected the company risk register; 11 (29%) perceived it to be the rig specific emergency response procedure; 8 (23.5%) chose the rig HSE case, and one (3%) picked the rig specific job safety analysis. While identifying the least effective tool, 15 (37.5%) respondents selected the company register 11 (32.4%); six (18.2%) went for the rig specific job safety analysis, and two (5.3%) picked the rig specific emergency response procedure. Figure 16 above summarises the responses to this question.

Despite the feedback on this question, a JSA may not be the most effective tool in preventing/reducing major accidents. A JSA is a tool that breaks down the task into manageable steps and focuses on identifying the hazards and control measure at each step for the whole task to be carried out safely; hence, JSAs are concerned with individual tasks rather than the bigger picture, and accordingly, they have limited ability to identify and manage major accidents (Occupational Safety and Health Adminstration, 2002). Since the company requires a JSA for each task, it appeared that the feedback was based on the tool that was being used the most rather than the most effective tool in reducing major accidents (Anon, 2015). Likewise, the selection, of what the staff considered the most effective tool in reducing the risk of major accidents, helped in fulfilling the first objective of this study.

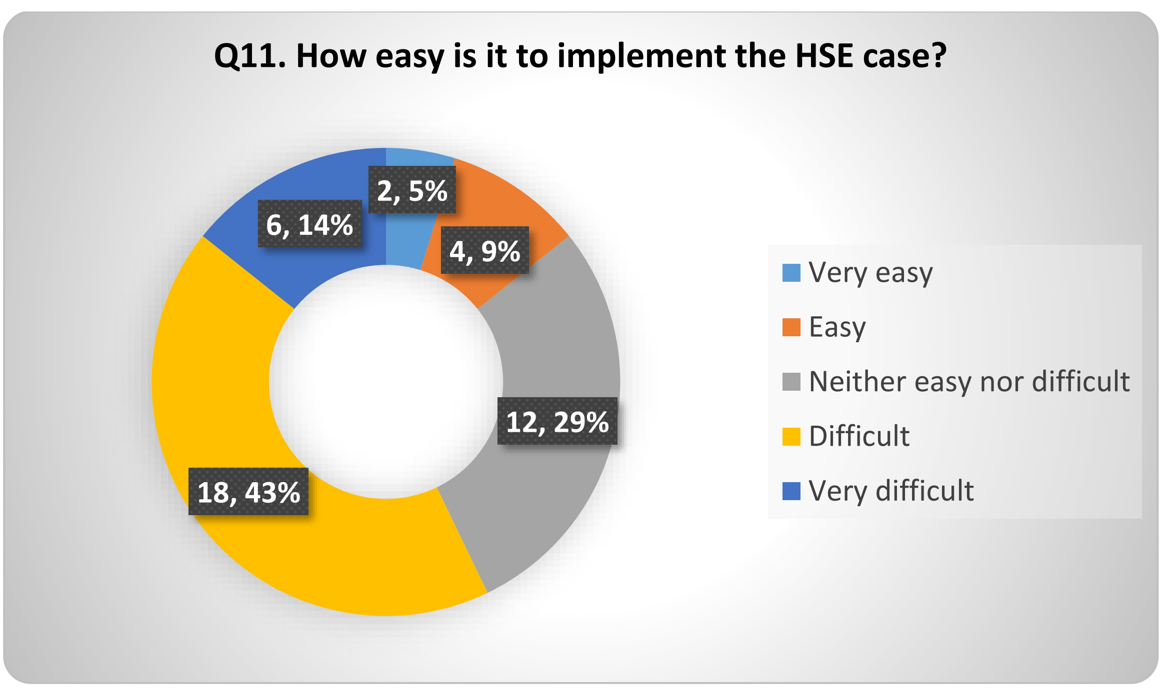


Figure 17 Ease of implementation of HSE cases

The eleventh question asked the respondents to identify how easily an HSE case can be implemented. There seemed to be an agreement that it was difficult to implement an HSE case: this was the opinion of 24 (57%) participants who either selected 'difficult' or 'very difficult' versus six (14%) who chose either 'easy' or 'very easy'. Overall, 18 (43%) respondents thought that it was difficult to implement an HSE case; six (14%) selected that it was very difficult while 12 (29%) remained neutral; four (9%) perceived that it was easy, and two (5%) mentioned that it was very easy. Figure 17 above sums up the responses regarding the ease of implementation of an HSE case.

The difficulties in applying HSE cases are not uncommon. The complexity of HSE cases, limited helpfulness to the shop floor workers and lack of understanding of best operationalisation options are some of the main reasons for the implementation hurdle of HSE cases (Wilkinson, 2002). A case in point is when the company management anticipates rigs to implement HSE cases without an implementation plan or additional resources. It is safe to conclude that without providing rigs with the right resources and guidance, it will not be easy for a rig to implement an HSE case.

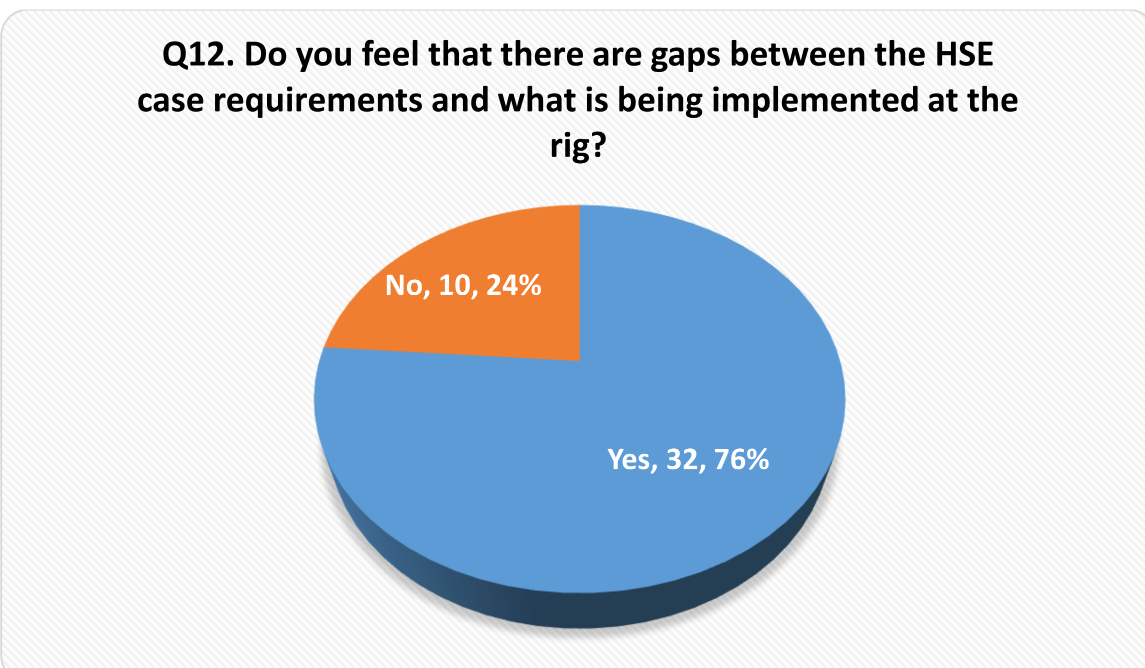


Figure 18 Gaps between HSE case requirements and what is being implemented at the rig

The twelfth question explored whether there were gaps between HSE case requirements and what was being implemented at the rig, and the thirteenth question asked the respondents to elaborate on their selection. In general, 32 (76%) respondents confirmed that they perceive that there were gaps while 10 (24%) declined. Figure 18 above summarises the respondents' perception.

Out of the 42 participants, 26 expanded on their responses. Difficulties in the implementation of an HSE case were supported by reasons such as having illiterate workers whom would struggle with the language of an HSE case, impracticality of an HSE case, complexity of an HSE case, inadequacy of the level of awareness and supervision at the rig, lack of details, having hundreds of pages that need to be read and understood, absence of training, and defectiveness of an HSE case review process. Moreover, one of the respondents mentioned that there would generally be gaps between what is written on paper and what is being implanted at the field. On the other hand, the minority who perceived that there were no gaps between the HSE case requirements and what was being implemented at the rig provided justifications that there were no significant gaps apart from minor differences; the HSE case was well written, and the rig staff would comply with any standards or instructions given to them.

The question was an extension of the previous question and was designed to ascertain the respondents' perception of the practicality of implementing an HSE case. In the author's experience, the gap between the requirements of an HSE case and rig practices is one of the challenges that most drilling contractors suffer from; narrowing or closing that gap requires additional resources which many drilling contractors are not willing to sacrifice. Nonetheless, the burden is placed on rig personnel to do their best to comply with and operationalise the rig HSE case.

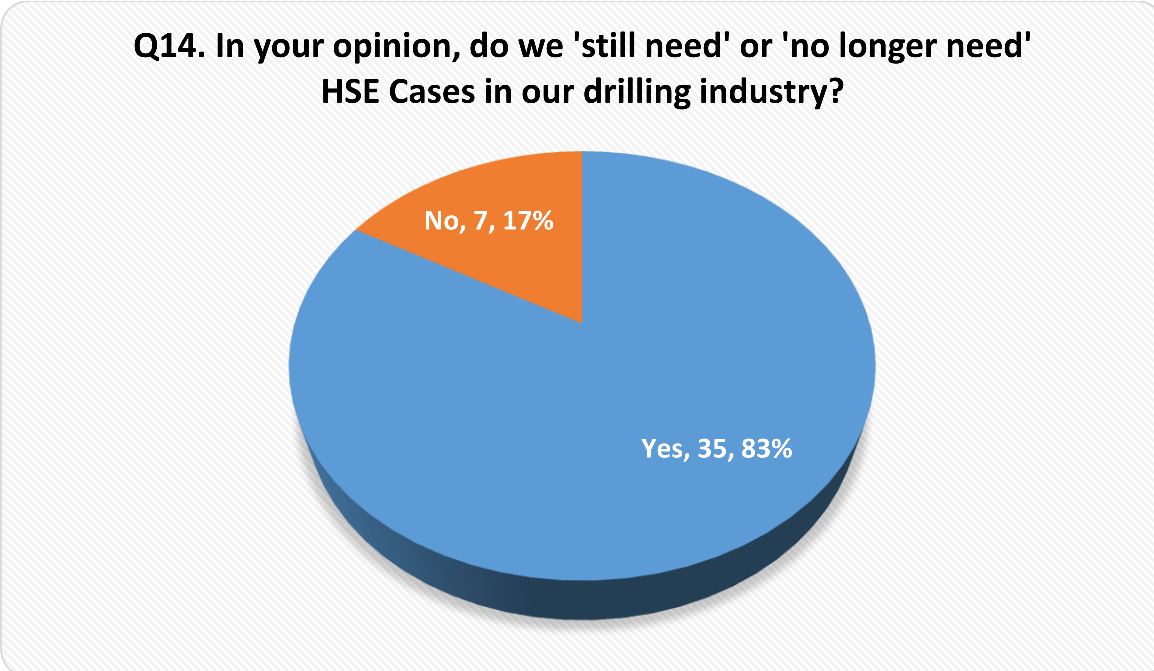


Figure 19 Participants' perception of whether HSE cases are still needed

The fourteenth question provoked the respondents to identify whether HSE cases were still needed in the drilling industry, and the fifteenth question requested elaboration on their selection. The responses were greatly inclined towards the need for HSE cases. In total, 35 (83%) answered that HSE cases were still needed while seven (17%) answered that they were no longer required. Figure 19 above gives an overview of the responses.

Out of the 42 participants, 26 elaborated on their selection. Those who stated that rig HSE cases were still needed argued that HSE cases were an effective tool in identifying hazards, controlling risks and preventing accidents; the HAZID workshop was useful; HSE cases provided good reference for safe operation; HSE cases contained sufficient details to prevent major accidents; HSE cases enabled the rig staff to be engaged rather than complying blindly; HSE cases adopted modern industry and local requirements. On the contrary, those who mentioned that HSE cases were no longer needed reasoned that the rig personnel were not familiar with the rig HSE case; the rig HSE case was a massive document, and management only supported the HSE case so they can get the rig personnel to sign the HSE critical task ownership sheet in order to be able to point fingers later when things go wrong. Figure 19 above provides a snapshot of the responses to whether HSE cases were still required.

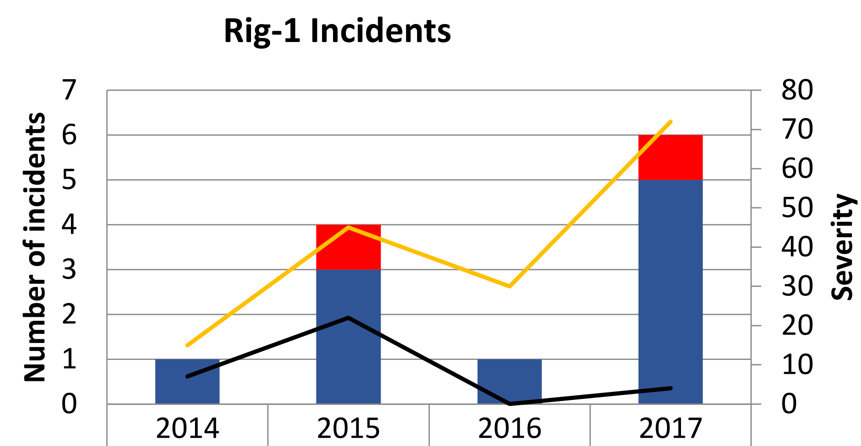
The question aimed at stimulating a response on whether HSE cases were still needed in the drilling industry. Both the proponents and opponents of safety cases provided justifications which had already been discussed earlier. In comparison with the previous responses, it seems that there was a higher level of certainty that HSE cases were still required. Despite the impediments that had been identified by the respondents, it appears that there was an agreement that HSE cases should not be abandoned.

The question assisted in understanding the perception of the rig personnel towards the future need of HSE cases. The question facilitated drawing a conclusion to the fourth hypothesis of the research.

9.3 Rig Incidents and Major Accident Risk

To attempt to correlate the effectiveness of HSE cases in reducing the risk of incidents and major accidents, the rig incident records were explored in-line with what had been discussed in the methodology section. The findings related to each rig are discussed below.

Rig-1



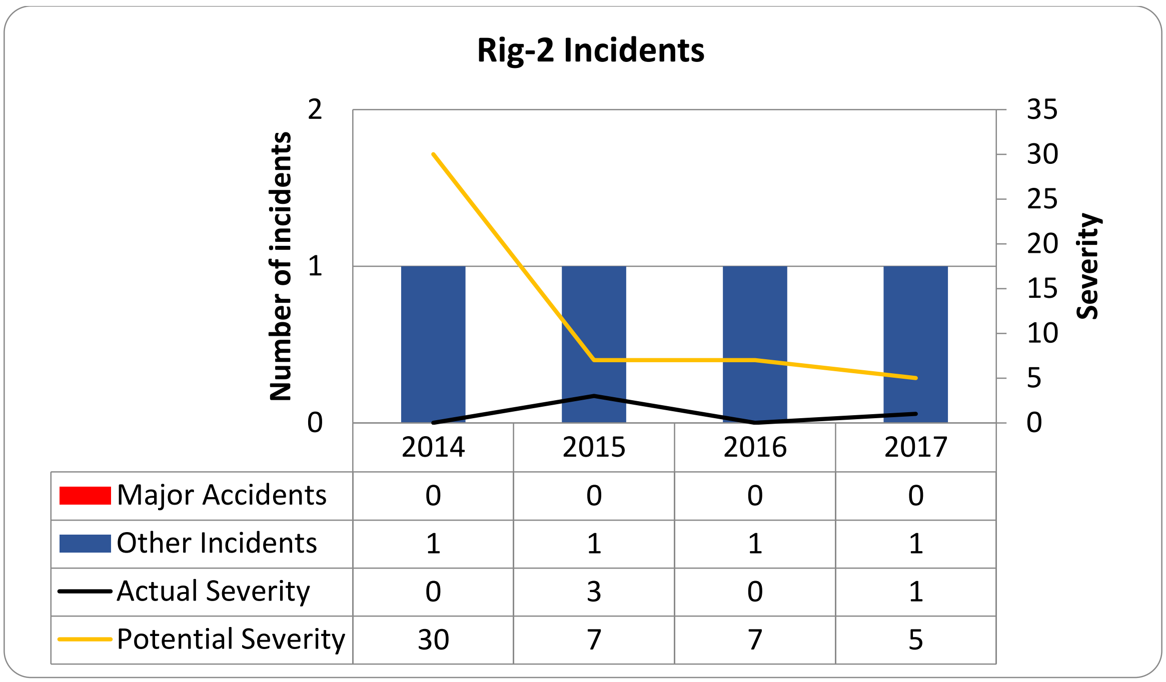
	2014	2015	2016	2017
Major Accidents	0	1	0	1
Other Incidents	1	3	1	5
Actual Severity	7	22	0	4
Potential Severity	15	45	30	72

Figure 20 Rig-1 Incidents

Rig-1 is oldest onshore drilling rig that had been operating for the national oil company in the drilling contractor's country of operation. Rig-1 HSE case was developed in late 2015 and early 2016. As shown in Figure 20 above, the rig had one major accident before the rig HSE case was developed and one major accident after. Overall, the rig had five incidents with actual severity of 29 and potential severity of 60 before the rig HSE case was developed, and seven incidents with actual severity of four and potential severity of 102 after the rig HSE case had been developed. The statistics show that there has not been a reduction in the number of major accidents, the number of incidents or incident potential severity; however, it appears that the incident actual severity was reduced following the introduction of the rig HSE case.

The level of utilisation of the HSE case at Rig-1 can be categorised as 'low'. Four out of five respondents stated that they would not encourage the development of an HSE case if they move to another rig. While only one respondent mentioned that the rig HSE case was being regularly utilised, two respondents mentioned that never referred to the rig HSE case and that the rig HSE case was being poorly supervised. Additionally, four respondents mentioned that they had not read the rig HSE case. Furthermore, none of the five respondents perceived that the HSE case could be easily implemented; also, the five respondents acknowledged that there were gaps between the HSE case requirements and what was being implemented at the rig. Lastly, three out of five declared that HSE cases might no longer be required. It seems that apart from the reduction in the incident actual severity, Rig-1 HSE case was not understood, utilised, supervised or appreciated.

Rig-2



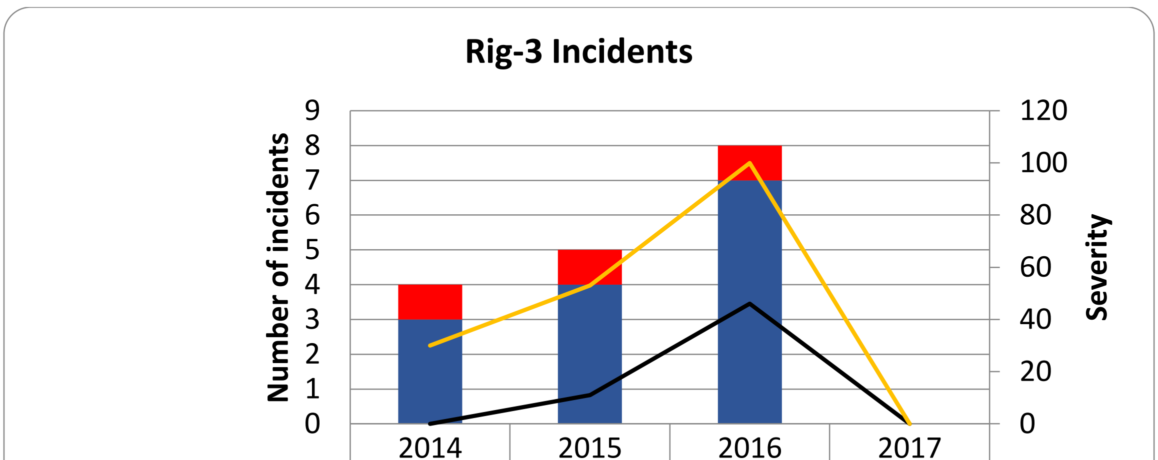
	2014	2015	2016	2017
Major Accidents	0	0	0	0
Other Incidents	1	1	1	1
Actual Severity	0	3	0	1
Potential Severity	30	7	7	5

Figure 21 Rig-2 Incidents

Rig-2 is a drilling rig that had been operating for the national oil company in the drilling contractor's country of operation. As shown in Figure 21 above, the rig had zero major accidents. In total, the rig had two incidents with actual severity of three and potential severity of 37 before the rig HSE case was developed, and two incidents with actual severity of one and potential severity of 12 after the rig HSE case had been developed. The statistics show that there has not been a reduction in the number of incidents; however, it appears that the incident actual and potential severities were reduced following the introduction of the rig HSE case.

The level of utilisation of the HSE case at Rig-1 can be categorised as ‘medium’. Although none of the five respondents disagreed that the HSE case was an effective tool for preventing major accidents, and all of them stated that they felt that the HSE case was important to them, only three mentioned that they would support developing an HSE case if they move to another rig, and three of them did not read the HSE case document. Moreover, there seemed to be an agreement that only the matrix of permitted operations (MOPO) was being utilised, and that the rig HSE case was being effectively supervised. Furthermore, the responses showed that there was a consensus that the respondents felt that the HSE case was difficult to implement and that there were gaps between the HSE case requirements and what was being implemented at the rig. One of the respondents mentioned that this was attributed to lack of training. Despite that, four out of five participants stated that HSE cases were still needed in the drilling industry.

Rig-3



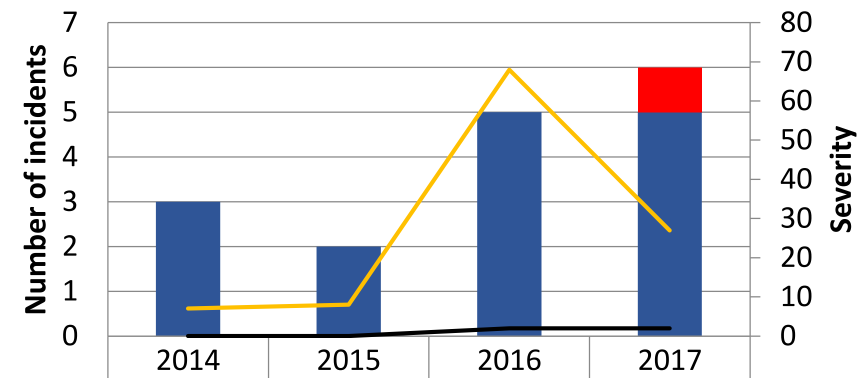
	2014	2015	2016	2017
Major Accidents	1	1	1	0
Other Incidents	3	4	7	0
Actual Severity	0	11	46	0
Potential Severity	30	53	100	0

Figure 22 Rig-3 Incidents

Rig-3 is a work-over rig that had been operating for the national oil company in the drilling contractor’s country of operation. As shown in Figure 22 above, the rig had two major accidents before the rig HSE case was developed and one major accident after. The last major accident was a fire incident and was one of the worst incidents in 2016 as it resulted in one fatality and various degree burns to five rig crew members. Overall, the rig had nine incidents with actual severity of 11 and potential severity of 83 before the rig HSE case was developed, and eight incidents with actual severity of 46 and potential severity of 100 after the rig HSE case had been developed. The data shows that there has been a reduction in the number of major accidents and incident potential severity; however, the number of other incidents and incident actual severity increased after the HSE case had been developed. Nonetheless, in 2017, the rig did not have any incidents, making Rig-3 the only rig with a clean record in any one year of the period under study.

The level of utilisation of the HSE case at Rig-3 can be categorised as ‘medium’. Three out of four participants supported the HSE case concept in almost every questions: they agreed that the rig HSE case was an effective tool for preventing major accidents; they perceived that the HSE case was important to them; they mentioned that they would support the development of a rig HSE case if they move to another rig; they ranked the rig HSE case as the most effective tool available for reducing major accident risks; they felt that the HSE case was being effectively supervised, particularly after the fire incident, and finally, the four respondents stated that the rig HSE case was still needed in the drilling industry. Nonetheless, it appeared that the only respondent, who was not as supportive, disagreed that the rig HSE case was an effective tool in reducing major accidents and elaborated that the rig had an HSE case; however, a major accident took place. Moreover, three respondents declared that they referred to the HSE case when needed, and one respondent expressed that the HSE case was being referred to almost daily. Furthermore, only two of the four respondents mentioned that they had read the complete HSE case document. Also, three responses indicated that the implementation of the rig HSE case was difficult. Lastly, two respondents felt that there were gaps between the HSE case requirements and what was being implemented at the rig.

Rig-4



	2014	2015	2016	2017
Major Accidents	0	0	0	1
Other Incidents	3	2	5	5
Actual Severity	0	0	2	2
Potential Severity	7	8	68	27

Figure 23 Rig-4 Incidents

Rig-4 is a drilling rig that had been operating for the national oil company in the drilling contractor's country of operation. As shown in Figure 23 above, the rig did not have any major accidents before having an HSE case; however, one major accident took place after. In total, the rig experienced five incidents with actual severity of zero and potential severity of 15 before the rig HSE case was developed, and 11 incidents with actual severity of four and potential severity of 95 after the rig HSE case had been developed. The data shows that following the introduction of the HSE case there has been a rise in the number of major accidents, other incidents, and incident actual and potential severities.

The level of utilisation of the HSE case at Rig-4 can be categorised as 'medium'. Only one of five participants perceived that the rig HSE case was an effective tool for preventing major accidents while one disagreed, and three remained on the fence. Moreover, four participants stated that they refer to the rig HSE case when needed and that they would not support the development of an HSE case if they move to another rig due to, amongst other reasons that were mentioned earlier, its level of complexity and poor level of supervision. Furthermore, the five participants mentioned that the rig HSE case was important to them and that the matrix of permitted operations was the part that was primarily utilised of the HSE case. Nonetheless, three mentioned that they did not read the rig HSE case document and that the rig HSE case was difficult to implement. Finally, despite that the rig HSE case was not selected as the most effective tool in reducing the risks of major accidents, the five participants agreed that HSE cases were still needed in the drilling industry.

Rig-5

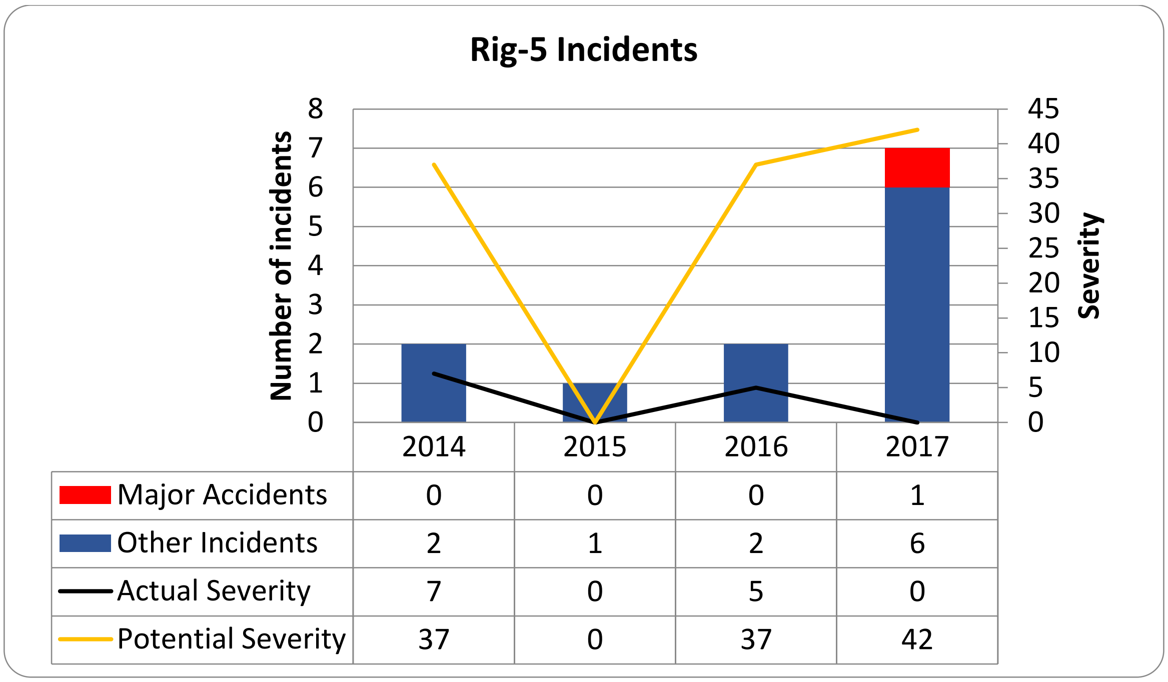
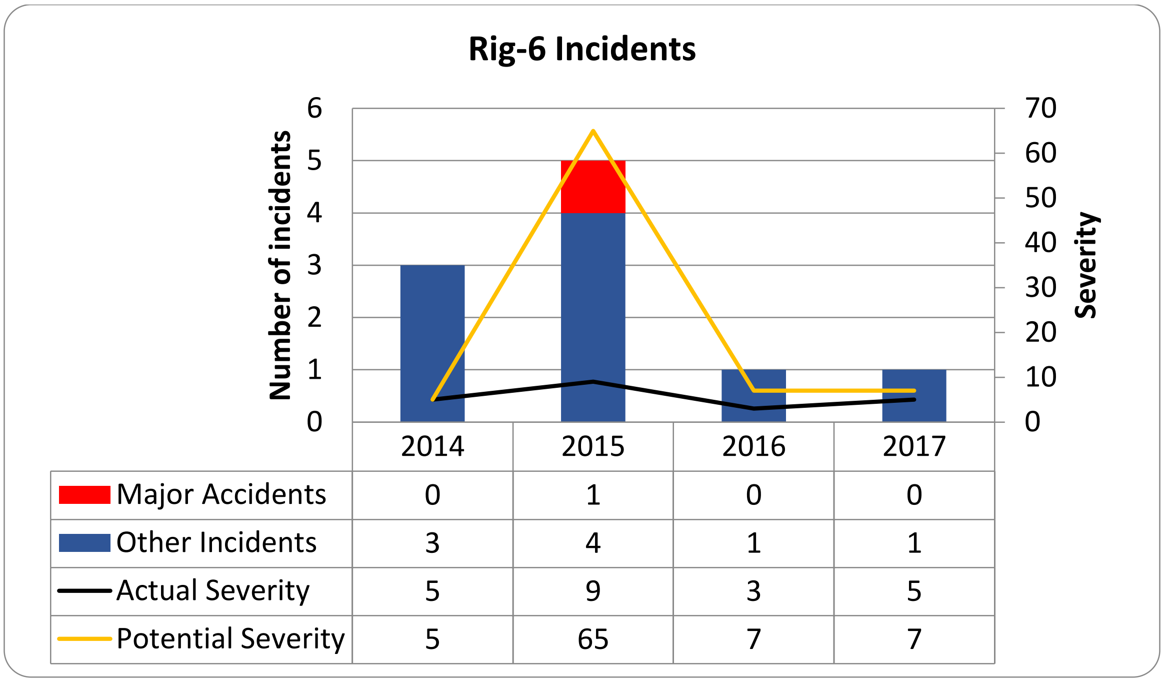


Figure 24 Rig-5 Incidents

Rig-5 is a work-over rig that had been operating for the national oil company in the drilling contractor’s country of operation. As shown in Figure 24 above, the rig did not have any major accidents before having an HSE case; however, one major accident took place after. In total, the rig experienced three incidents with actual severity of seven and potential severity of 37 before the rig HSE case was developed, and nine incidents with actual severity of five and potential severity of 79 after the rig HSE case had been developed. It appears that following the introduction of the HSE case, the incident actual severity was the only aspect that decreased while the number of major accidents, other incidents and incident potential severity increased.

None of the staff of Rig-5 participated in the survey. The author suspects that the rig manager instructed the rig supervisors not to take part in the study. Consequently, it was not possible to determine the level of utilisation of the rig HSE case; hence, the author subjectively evaluated the level of utilisation to be ‘low’ based on his experience during the period at which he was supervising the rig.

Rig-6



	2014	2015	2016	2017
Major Accidents	0	1	0	0
Other Incidents	3	4	1	1
Actual Severity	5	9	3	5
Potential Severity	5	65	7	7

Figure 25 Rig-6 Incidents

Rig-6 is a work-over rig that had been operating for the national oil company in the drilling contractor’s country of operation. As shown in Figure 25 above, the rig had one major accident before having an HSE case and none after. Overall, the rig suffered eight incidents with actual severity of 14 and potential severity of 70 before the rig HSE case was developed, and two incidents with actual severity of eight and potential severity of 14 after the rig HSE case had been developed. It appears as if the introduction of the HSE case successfully reduced the risk of major accidents and other rig incidents.

The level of utilisation of the HSE case at Rig-6 can be categorised as ‘low’. Three out of five participants mentioned that they agree that the rig HSE case was an effective tool for preventing major accidents while two remained neutral. Four participants stated that the rig HSE was important to them; however, four participants declared that they had not read the rig HSE case document, and three communicated that they would not support the development of a new rig HSE case if they move to another rig. Moreover, none of the responses expressed that the HSE case implementation was easy, and all the five responses identified that there were gaps between the HSE case requirements and the rig practices. Nonetheless, the five participants agreed that HSE cases were still needed, and the only comment was that the HSE case workshop was useful.

Rig-1:6

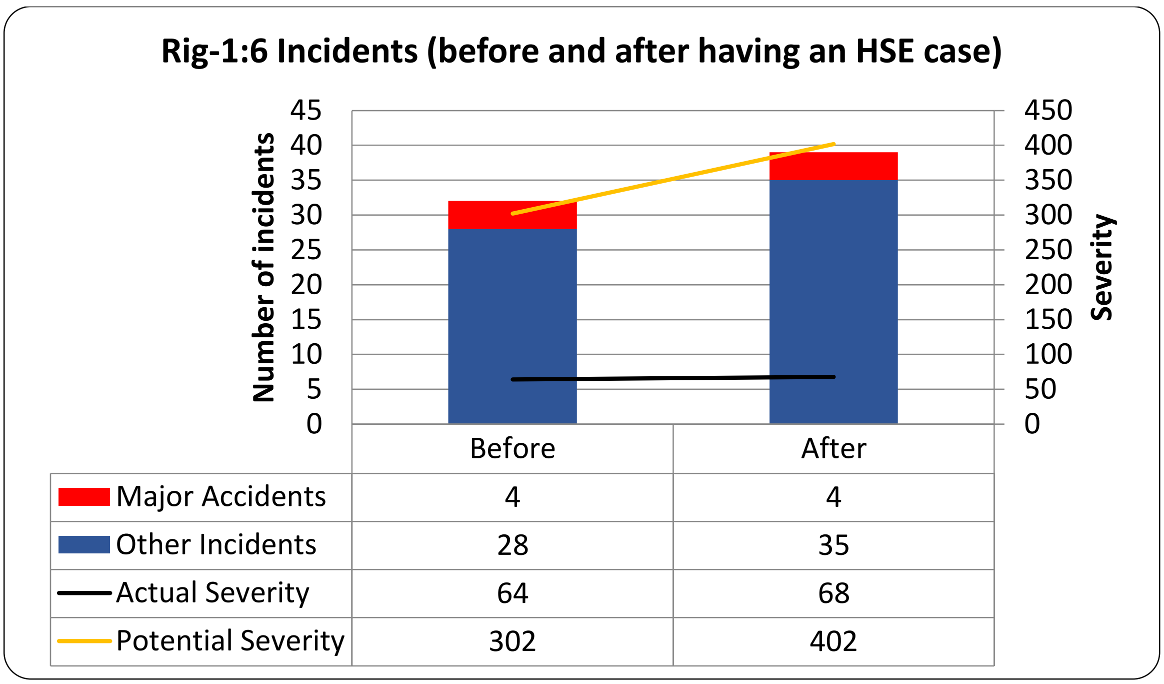


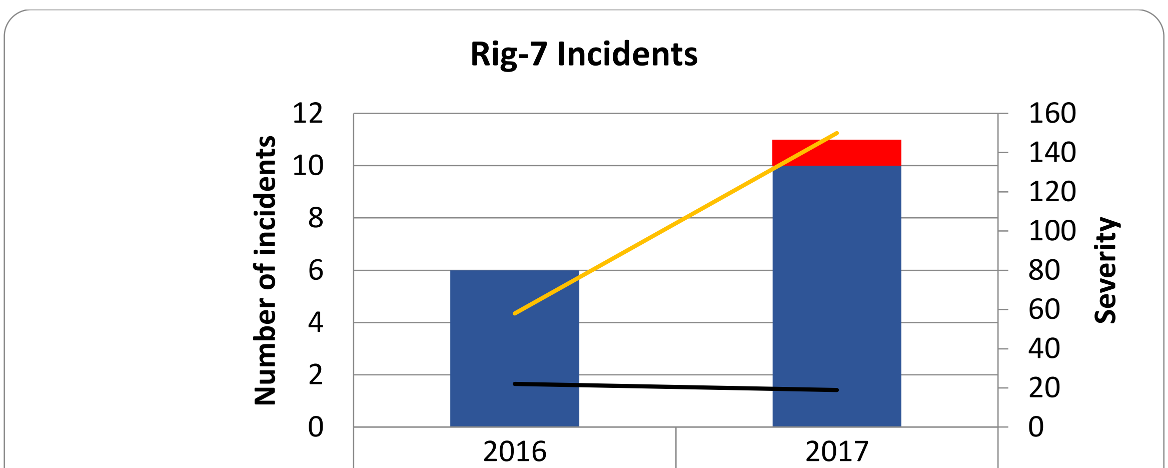
Figure 26 Combined incident data before and after having an HSE case for Rig-1:6

To attempt to have an overview of the potential impact of the introduction of HSE cases on the six onshore rigs, the incident data, for two years before and after the HSE case was developed, were combined as shown in Figure 26 above. The figures show that while the number of major accidents plateaued, the number of other rig incidents, and the risk of major accidents and other rig incidents experienced an uptrend.

To attempt to determine whether there was statistical evidence that the number of major accidents and other rig incidents, before and after introducing rigs'

HSE cases, was significantly different from zero, a paired t-test was conducted. The null hypothesis was considered to be that HSE cases do not reduce the number of major accidents and other rig incidents. Since the number of major accidents was the same before and after the introduction of an HSE case, there was not a significant difference in the scores for major accidents before the HSE case (M=0.67, SD=0.816) and major accidents after the HSE case (M=0.67, SD=0.516) conditions; t (5) =0.0, p = 1.0. Similarly, there was not a significant difference in the scores for other rig incidents before the HSE case (M=4.67, SD=2.066) and other rig incidents after the HSE case (M=5.83, SD=3.251) conditions; t (5) =-0.759, p = 0.489. In line with what has been described in the methodology section, and since the probability (p) was more than 0.05, the null hypothesis was retained. In short, the outcome showed that the introduction of HSE cases did not result in a difference, in the number of major accident and other rig incidents, that is statistically significant. This result contributed to the realisation of the second and third objectives of this study.

Rig-7



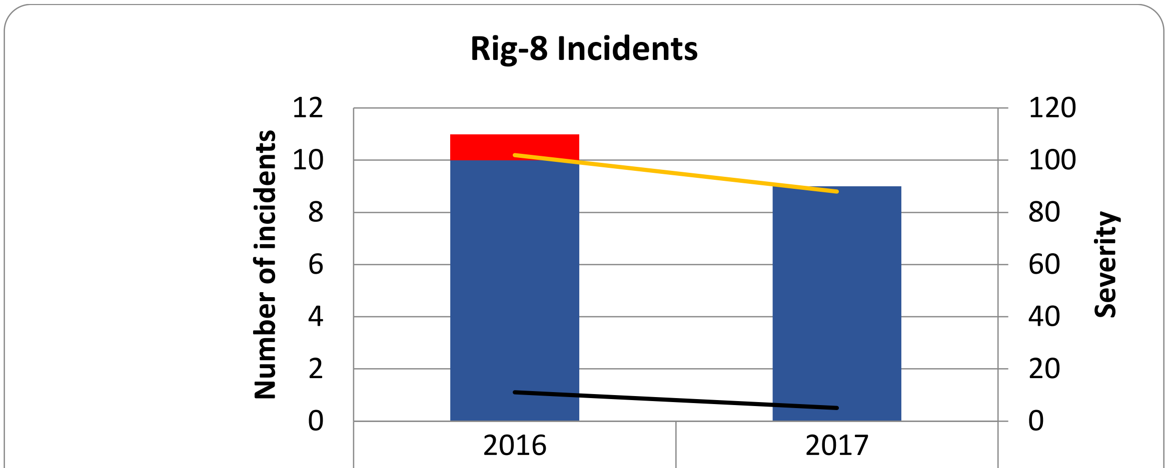
	2016	2017
Major Accidents	0	1
Other Incidents	6	10
Actual Severity	22	19
Potential Severity	58	150

Figure 27 Rig-7 Incidents

Rig-7 is a drilling rig that was built for the national oil company in late 2015. The HSE case of Rig-7 had been developed before the rig started operation at the beginning of 2016. Figure 27 above shows that, apart from the slight decrease in incident actual severity, the risk of major accidents and other incidents increased in the first two years of operation: in 2016, the rig suffered six incidents with actual severity of 22 and potential severity of 58 while in 2017, the rig had one major incident and 10 other incidents with actual severity of 19 and potential severity of 150.

The level of utilisation of the HSE case at Rig-7 can be categorised as 'low'. Only four staff from Rig-7 completed the questionnaire. They all agreed that the rig HSE case was an effective tool for preventing major accidents, and they all perceived that it was important to them. Moreover, two of the responses regarding the effectiveness of supervision of the HSE case were related to whom from the rig management team was on shift. Furthermore, two of the respondents mentioned that they would support the development of a new HSE case if they move to another rig, and the other two declined. Additionally, three respondents stated that they refer to the HSE case when needed, and one declared that it was not being used. Also, two responses were in favour of the matrix of permitted operations as the part that was being used the most. Lastly, although three respondents mentioned that they have not read the HSE case document and that the HSE case was not easy to be implemented, and all agreed that there were gaps between the HSE case requirements and its implementation, three respondents expressed that the drilling industry still needs HSE cases.

Rig-8



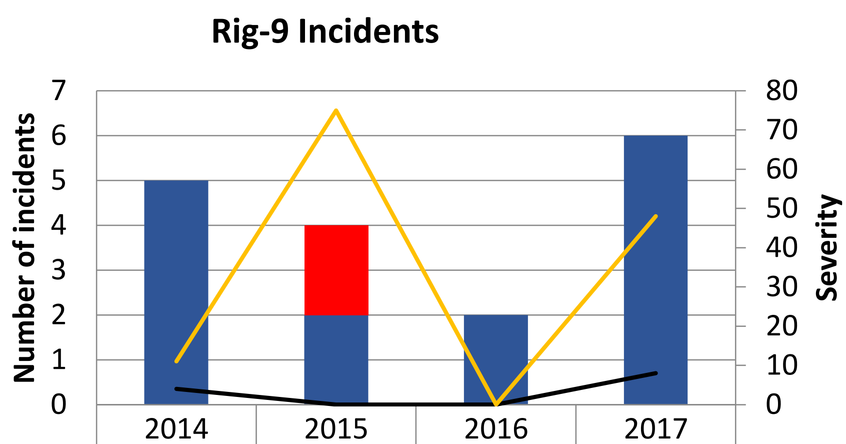
	2016	2017
Major Accidents	1	0
Other Incidents	10	9
Actual Severity	11	5
Potential Severity	102	88

Figure 28 Rig-8 Incidents

Rig-8 is a drilling rig that was built at almost the same time as Rig-7. The rig started to operate for the national oil company at the beginning of 2016, and similar to Rig-7, Rig-8 had an HSE case developed during the rig start-up. Figure 28 above shows that the risk of major accidents and other incidents slightly decreased in the second year of operation: in 2016, the rig suffered one major accident and 10 other incidents with actual severity of 11 and potential severity of 102 while in 2017, the rig had nil major accidents and nine other incidents with actual severity of five and potential severity of 88.

The level of utilisation of the HSE case at Rig-8 can be categorised as 'low'. Out of four participants, two agreed that the rig HSE case was an effective tool for preventing major accidents while one remained neutral, and one disagreed. Moreover, three participants perceived that the rig HSE case was important to them; however, three responses rejected the idea of initiating a request for developing an HSE case if the respondents move to another rig. Furthermore, two respondents stated that they refer to the HSE case when needed while one communicated that it was being referred to on a daily basis, and one declared that it was not being used. Likewise, the matrix of permitted operation was the part that the respondents use the most; however, there was in agreement that job safety analysis was the most effective tool in reducing risks of major accidents. In addition, none of the respondents evaluated the process of implementing the HSE case as easy, and all agreed that there were gaps between what was written in the HSE case and what was being implemented at the rig. While two respondents declared that they had not read the HSE case document, three respondents communicated that HSE cases are still required in the drilling industry.

Rig-9



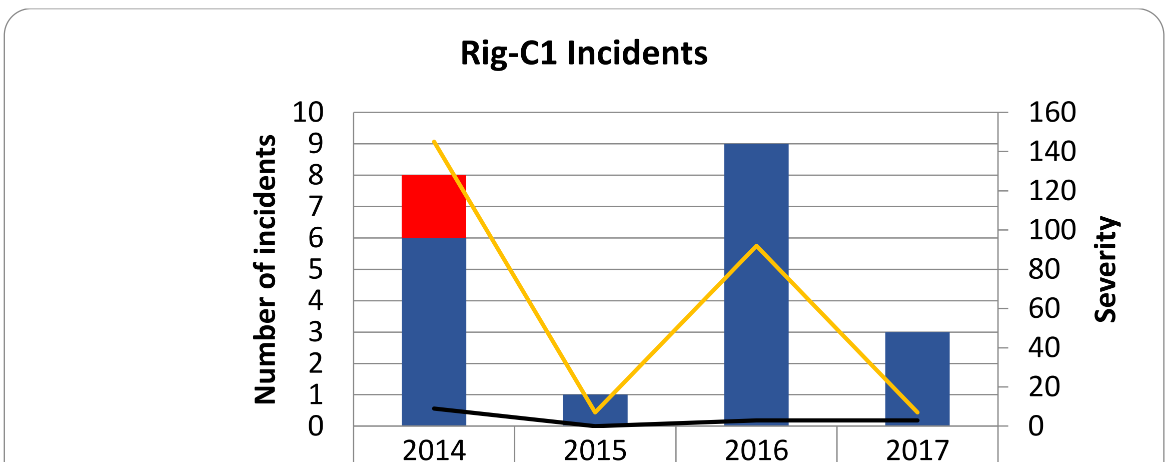
	2014	2015	2016	2017
Major Accidents	0	2	0	0
Other Incidents	5	2	2	6
Actual Severity	4	0	0	8
Potential Severity	11	75	0	48

Figure 29 Rig-9 Incidents

Rig-9 is an offshore rig that had been working with reputable oil companies for several years. Figure 29 above captures the incident data for the rig from 2014 to 2017. During this period, the rig had an HSE case that was being enforced by an international oil company; despite that, the rig suffered two major accidents in 2015. Moreover, it appears that the number of other incidents and incident severities fluctuating with an upward trend.

The level of utilisation of the HSE case at Rig-9 can be categorised as ‘high’. Three out of five respondents agreed that the rig HSE case was an effective tool for preventing major accidents while two disagreed and commented that the way HSE cases were written did not commensurate with the level of literacy of the rig staff, and once it was developed, it was placed on a bookshelf and not operationalised. Moreover, two respondents perceived that the rig HSE case was important to them; two were not sure, and one declined. Furthermore, three respondents supported the idea of initiating an HSE case if they move to another rig, and two opposed. Also, the five respondents mentioned that they referred to the rig HSE case either regularly or when needed. Additionally, Rig-9 was the only rig with responses that indicate that the HSE case critical tasks were being utilised in addition to the matrix of permitted operations. Rig-9 was also the only rig that ranked the rig HSE case as the most effective tool reducing risks of major accidents. Similarly, Rig-9 was the only rig where the five respondents expressed that the HSE case was being effectively supervised and enforced. Although four respondents stated that HSE cases were still needed, three identified that there were gaps in implementation, and only one respondent stated that they were easy to implement.

Rig-C1



	2014	2015	2016	2017
Major Accidents	2	0	0	0
Other Incidents	6	1	9	3
Actual Severity	9	0	3	3
Potential Severity	145	7	92	7

Figure 30 Rig-C1 Incidents

Rig-C1 is one of four offshore rigs that formed the control group. As mentioned earlier, the purpose of a control group is to attempt to quantify some of the extraneous variables. Rig-C1 has been working, without an HSE case in place, for one of the international oil companies for several years. Figure 30 above demonstrates that there has been a downtrend in the number of major accidents, and incident actual and potential severities.

Rig-C2

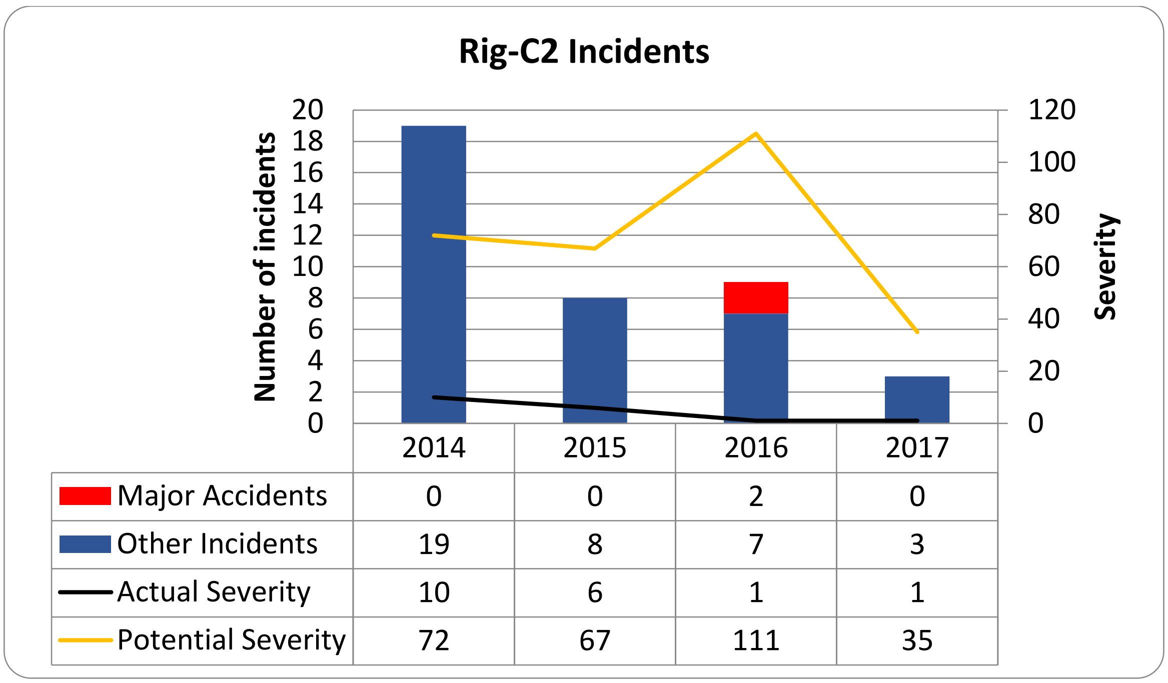


Figure 31 Rig-C2 Incidents

Rig-C2 is another control rig. Rig-C2 has been working for some international oil companies without having an HSE case. Figure 31 above shows that in 2016, the rig suffered two major accidents that surged the incident potential severity; however, it appears that in the other three years, the risk of major accident and other incidents have been reducing. Figure 33

Data comparison – Rigs that have been working for international oil companies

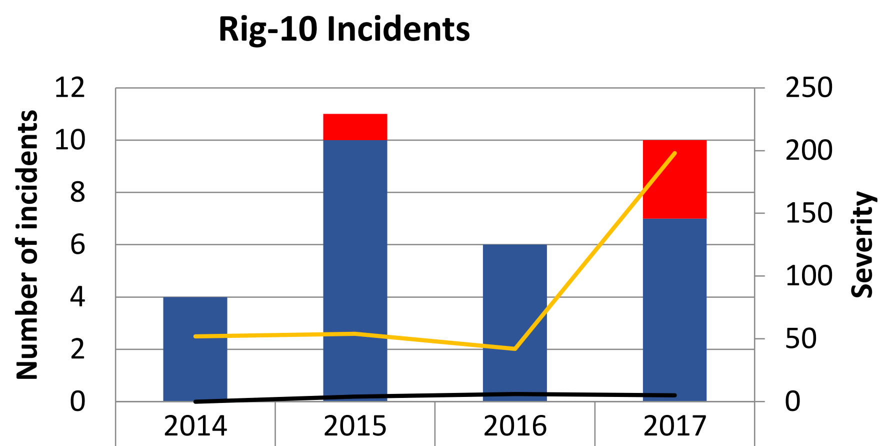
Table 2 Rig-C1 and Rig-C2 averaged data versus Rig-9 figures

Rig	Rig-C1 and Rig-C2 averaged data	Rig-9 figures
Major Accidents	2	2
Other Incidents	29	15
Actual Severity	17	12
Potential Severity	269	134

Rig-C1 and Rig-C2 have been selected as a control group for Rig-9 to quantify some of the extraneous variables. As mentioned earlier, in the author's experience, the safety standard at the rig is mostly governed by the standard that has been set by the operator/client oil company. Rig-C1 and Rig-C2 have been operating for international oil companies with more or less the same standard as Rig-9 but without having an HSE case. Table 2 above shows that Rig-9 suffered the same number of major accidents compared with the averaged data of the control group. Moreover, the number of other incidents, incident actual and potential severities were lower.

To establish whether there is statistical evidence that the incident data of Rig-9 and the average incident data of the control group are significantly different, an independent t-test was carried out. The null hypothesis was considered to be that the HSE case of Rig-9 did not make a difference in the number of major accidents and other rig incidents compared with the average incidents of the control group. The test showed that there was not a significant difference in the scores for major accidents of Rig-9 ($M=0.5$, $SD=1.0$) and Rig-C1 and Rig-C2 ($M=0.5$, $SD=0.577$) conditions; $t(6)=0.0$, $p = 1.0$. Similarly, there was not a significant difference in the scores for other rig incidents of Rig-9 ($M=3.75$, $SD=2.062$) and Rig-C1 and Rig-C2 ($M=7.25$, $SD=4.349$) conditions; $t(6)=-1.454$, $p = 0.196$. Subsequently, the null hypothesis was retained since the probability was more than 0.05 ($p>0.05$). From this, it can be concluded that although it appears that the risk of major accident and incidents was lower on the rig with an HSE case, the difference was not statically significant.

Rig-10



	2014	2015	2016	2017
Major Accidents	0	1	0	3
Other Incidents	4	10	6	7
Actual Severity	0	4	6	5
Potential Severity	52	54	42	198

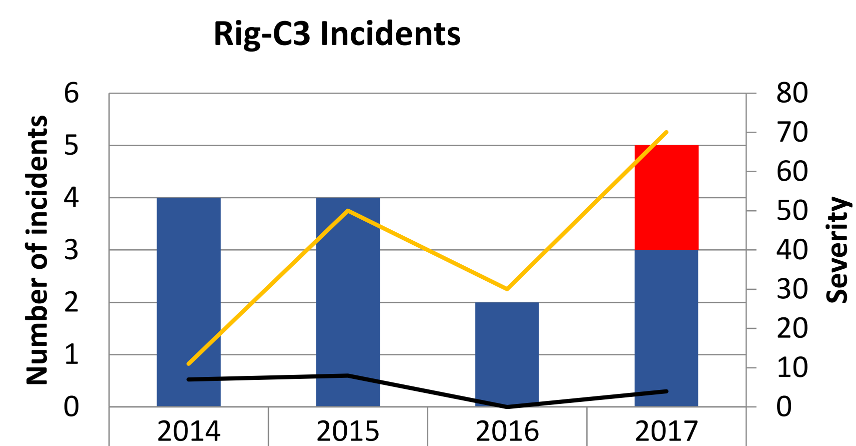
Figure 32 Rig-10 Incidents

Rig-10 is an offshore rig that started working for the national oil company in 2014. The rig had an HSE case since conception. Figure 32 above illustrates that, throughout the years, there has not been a substantial reduction in the risk of major accidents and other incidents. In 2017, Rig-10 suffered triple the number of major accidents since start-up; consequently, in 2017, the incident potential severity was almost four times the severity of any of the previous years.

The level of utilisation of the HSE case at Rig-10 can be categorised as 'high'. In general, the attitude toward the rig HSE case was more positive than the other rigs. The five participants agreed that the rig HSE case was an effective tool for preventing major accidents, and they all perceived that the rig HSE case was important to them and mentioned that they either referred to it regularly or when needed. Also, four participants mentioned that they would support the initiative of requesting an HSE case to be developed if they move to another rig and ranked the rig HSE case as the most effective tool in reducing the risk of major accidents.

Moreover, beside the matrix of permitted operations, two respondents stated that they had been using the whole HSE case at work. Furthermore, Rig-10 was the only rig to have an agreement that there were no gaps between the HSE case requirements and what was being implemented at the rig, and that HSE cases were still required in the drilling industry. Nonetheless, three respondents declared that they had not read the complete HSE case document.

Rig-C3



	2014	2015	2016	2017
Major Accidents	0	0	0	2
Other Incidents	4	4	2	3
Actual Severity	7	8	0	4
Potential Severity	11	50	30	70

Figure 33 Rig-C3 Incidents

Rig-C3 is the third control rig. Rig-C3 had been working for the national oil company for several years without having an HSE case. Figure 33 above shows that the rig had been maintaining a major-accident-free record until 2017 when the rig suffered two major accidents. Furthermore, the number of other incidents and incident actual severity showed a downtrend; nonetheless, due to the major accidents, the incident potential severity boomed in 2017.

Rig-C4

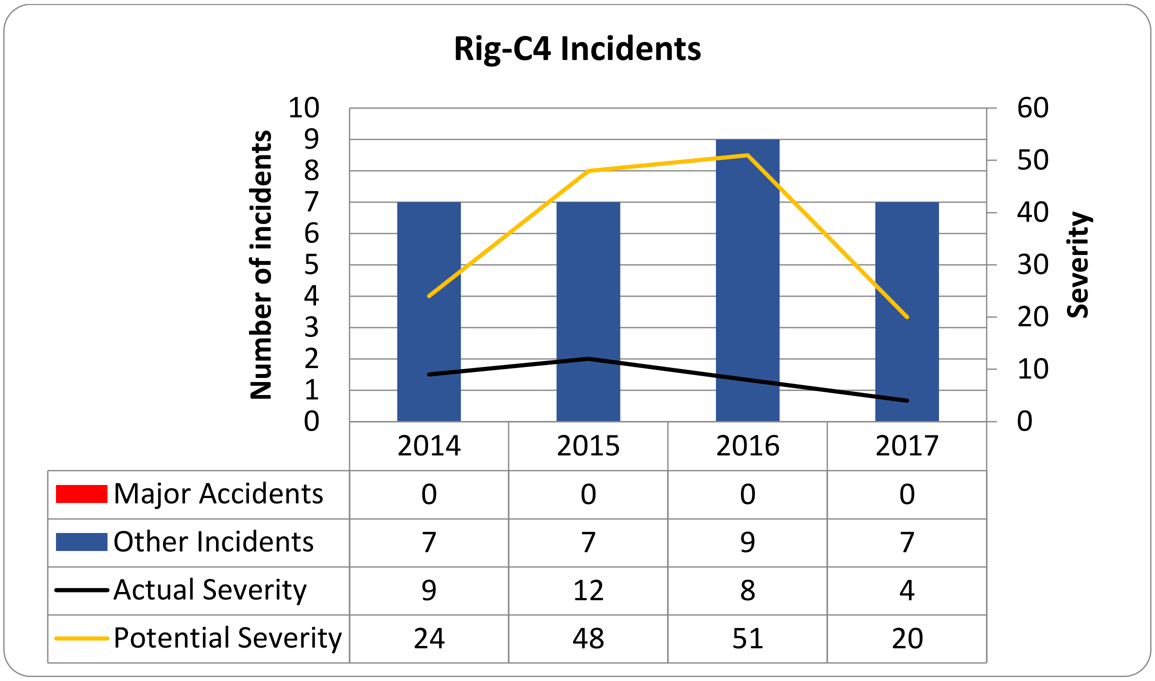


Figure 34 Rig-C4 Incidents

Rig-C4 is the fourth offshore rig in the control group. Rig-C4 had been working for the national oil company for several years without having an HSE case. Figure 34 above shows that the rig did not suffer any major accidents and had been, almost, maintaining a constant number of incidents over the years.Figure 33

Data comparison – Rigs that had been working for the national oil company

Table 3 Rig-C3 and Rig-C4 averaged data versus Rig-10 figures

Rig	Rig-C3 and Rig-C4 averaged data	Rig-10 figures
Major Accidents	1	4
Other Incidents	23	27
Actual Severity	26	15
Potential Severity	152	346

Rig-C3 and Rig-C4 are the other two rigs in the control group. They had been operating without an HSE case for the national oil company and were selected to quantify some of the extraneous variables for Rig-10. Table 3 above shows that Rig-10 suffered four times the number of major accidents compared with the averaged data of the control group. Moreover, apart from the incident actual severity which was lower than the control group, it appeared that the risk of major accidents and other incidents were higher at Rig-10.

To establish whether there is statistical evidence that the incident data of Rig-10 and the average incident data of the control group were significantly different, an independent t-test was carried out. The null hypothesis was considered to be that the HSE case of Rig-10 did not make a difference, in the number of major accidents and other rig incidents, compared with the average incidents of the control group rig. The test showed that there was not a significant difference in the scores for major accidents of Rig-10 (M=1.0, SD=1.414) and Rig-C3 and Rig-C4 average statistics (M=0.25, SD=0.5) conditions; t (6) =1.0, p= 0.356. Similarly, there was not a significant difference in the scores for other rig incidents of Rig-10 (M=6.75, SD=2.5) and Rig-C3 and Rig-C4 average statistics (M=5.75, SD=0.5) conditions; t (6) =0.784, p= 0.463. Subsequently, the null hypothesis was retained. From this, it can be concluded that although it appears that the risk of major accident and incidents was higher on the rig with an HSE case, the difference was not statically significant.

9.4 Investigating the correlation between the level of utilisation of the HSE case and the number of major accidents and other incidents

To investigate the potential relationship between the level of utilisation of rig HSE cases on the risk of major accidents and other rig incidents, a one-way ANOVA technique was applied. This statistical procedure investigated if there were any statistically significant differences between the two variables. The level of utilisation within the company appeared to be below average: the feedback from five rigs indicated low use; three rigs indicated medium use, and the two offshore rigs demonstrated high use. Table 4 below summarises the test data. The test showed that there was not a significant effect of the level of utilisation of the rig HSE case on the number of major accidents at the $p<0.05$ level for the three conditions [F (2, 7) = 0.547, p = 0.601]. Moreover, there was not a significant effect of level of utilisation of the rig HSE case on the number of incidents at the $p<0.05$

level for the three conditions [F (2, 7) = 0.469, p = 0.644]. In short, it appeared that there was not a relationship between the level of utilisation of a rig HSE case and the risk of major accidents and other rig incidents.

Table 4 Level of utilisation of HSE cases versus the number of major accidents and other rig incidents

Rig	Level of utilisation of the HSE case	Number of Major accidents (2016-2017)	Number of other rig incidents (2016-2017)
Rig-1	Low	1	6
Rig-2	Medium	0	2
Rig-3	Medium	1	7
Rig-4	Medium	1	10
Rig-5	Low	1	8
Rig-6	Low	0	2
Rig-7	Low	1	16
Rig-8	Low	1	19
Rig-9	High	0	8
Rig-10	High	3	10

10 Conclusions

10.1 The aim of the study

The aim of this study has been to investigate the contemporary effectiveness of non-regulated HSE cases in one of the national drilling companies in the Middle East. The thesis started with an introduction of the origin of safety cases and their development throughout the years. The literature review indicated that the contemporary effectiveness of non-regulated HSE cases is questionable. The evidence suggested that although safety cases originated around three decades ago, only ten countries require safety cases as part of their legislation. Moreover, where safety cases are required as a best practice, there seemed to be an agreement that the absence of a powerful regulator diminishes operators' efforts in ensuring that an HSE case is well prepared. Furthermore, it appeared that the cost-benefit analysis had failed due to difficulties in associating a monetary value to rare, yet disastrous events. It seemed that a firm link, between HSE cases and its ability to reduce major accident risks, has not yet been proven. Other benefits were identified for HSE cases; however, those were communicated to be fundamental components of any HSE management system; hence, non-regulated HSE cases may be a waste of resources with no added value to a drilling rig.

The research took place within one of the national drilling companies in the Middle East. The rig fleet, workforce and work arrangements of the drilling contractor were described in the setting section. Furthermore, the HSE duties and HSE organisation were outlined to provide a context on how HSE was being managed within the company. While taking into consideration the ethical issues related to the different research stakeholders, the study attempted to answer the research problem by looking into the effectiveness of non-regulated HSE cases in reducing the risk of major accidents and other rig incidents.

The methodology section provided an overview of the techniques that had been used to conduct the research. The section discussed the study design, type, data collection methods, population, validity and reliability, and data analysis. The methodology part structured the approach to fulfilling the study aim and objectives.

10.2 The First Objective

The first objective has been to determine the level of utilisation of non-regulated safety cases on the day-to-day running of drilling rigs. This was achieved by developing and sending a questionnaire to the rigs that owned HSE cases. The questionnaire provided a mix of qualitative and quantitative data that quantified and explained the participants' perceptions. Several considerations were taken into account to overcome the challenges of using a questionnaire. Before administering the questionnaire, it had been tested, and its validity and reliability had been assured. The questionnaire was administered electronically to 50 rig supervisors; out of which, 42 responded. The rig supervisors provided insights into the level of utilisation, importance, ease of implementation, the degree of enforcement and extent of the operationalisation of HSE cases at their rigs. Before analysing the data that was obtained from the questionnaire, the data had been edited, cleaned and coded.

The level of utilisation of non-regulated HSE cases was evaluated to be below average. The questionnaire responses showed that a rig HSE case was not perceived as the most effective tool in reducing the risks of major accidents. Moreover, two-thirds of the respondents, who are rig supervisors, had not read the complete HSE case document and might not have been aware of what was required. Furthermore, three-quarters of the respondents identified that there were gaps between the HSE case requirements and rig practices. From this, it can be inferred that safety cases are not being adequately utilised during the day-to-day operation of the rigs.

10.3 Hypothesis – H1

The first hypothesis has been that non-regulated HSE Cases are not being utilised, by the rig team, to manage the risks arising from the rig activities. Based on what has been discussed above, the hypothesis has been confirmed.

10.4 The Second Objectives

The second objective has been to ascertain the ability of non-regulated safety cases in reducing the risk of major accidents. This was achieved by examining the company incident records and filtering out the ones that fell under the definition of a major accident. Additionally, a risk severity matrix was developed to quantify the actual and potential severities of each other incident. To investigate the influence of HSE cases, major accident risk before and after the introduction of a rig HSE case was compared for some of the rigs; major accident trends were analysed for other rigs that had HSE cases since start-up, and for two rigs that had HSE cases for several years, the risk of major accidents was compared with a control group in an attempt to quantify some of the extraneous variables that affected the risk of major accidents. Moreover, various statistical analyses were carried out to investigate the strength of association.

It appeared that HSE cases did not result in a reduction in the number of major accidents. The evidence showed that not only the number of major accidents was the same before and after the introduction of HSE cases, and between a rig with an HSE case and rigs without in the control group but also one of the rigs with an HSE case had four times the number of major accidents compared with its control group. As discussed earlier, although an HSE case is one of the barriers, amongst many, that control major accident hazard, it is safe to conclude that HSE cases have not succeeded to fulfil its primary purpose.

10.5 Hypothesis – H2

The second hypothesis has been that non-regulated HSE cases do not reduce the risk of major accidents. Based on what has been discussed above, the hypothesis has been confirmed.

10.6 The Third Objectives

The third objective has been to examine the ability of non-regulated safety cases in reducing the risk of other rig incidents. The same technique, which was mentioned above, was used to count the number of other rig incidents, and the severity matrix was used to quantify the actual and potential severity of each incident. The evidence showed that the number of incidents, incident actual severity and incident potential severity after the introduction of an HSE case increased. Moreover, the rigs that had HSE cases since start-up showed contradictory trends: one rig exhibited a reduction in the number and severity of incidents while the other rig demonstrated otherwise. The same contradiction was revealed when the rigs in the control groups were compared with the rigs that had HSE cases for several years. The evidence showed that although it was not possible to establish the ability of HSE cases in reducing the risk of other rig incidents over the years, the introduction of HSE cases to six rigs did not succeed in decreasing the risk of other rig incidents. The outcome agreed with the viewpoint that was held by Wilkinson (2002:11) who suggested that safety cases were, "not a panacea and they will not prevent all major accidents, nor less serious ones" (sic).

10.7 Hypothesis – H3

The third hypothesis has been that non-regulated HSE cases do not reduce the risk of other rig incidents. Based on what has been discussed above, the hypothesis has been confirmed.

10.8 Hypothesis – H4

The fourth hypothesis has been that in-line with the previous three hypotheses above, non-regulated HSE cases, nowadays, may no longer be required. Although the previous three hypotheses were accepted, the questionnaire responses demonstrated otherwise: five-sixths of the participants indicated that HSE cases were still needed in the drilling industry. It appeared that despite the hurdles in implementing an HSE case along with the evidence of its ineffectiveness, the rig supervisors perceived that HSE cases are still required; hence, the hypothesis has been refused.

10.9 Overall Conclusion

It is safe to conclude that the aim and objectives of this study have been fulfilled. The contemporary effectiveness of non-regulated HSE cases has been investigated by verifying its level of use which was determined to be below average; the ability of non-regulated HSE case in reducing the risk of major accident and other rig incident was examined which was evidently proven ineffective. Moreover, three of the research hypotheses were confirmed, and one was refused.

11 Recommendations

11.1 Recommendations to Company Management

Based on the outcome of this study, several recommendations are proposed for the drilling contractor. The recommendations aim at familiarising the company staff with the contents of their respective rig HSE case, closing the gaps between HSE case requirements and rig practices, and assisting with the operationalisation of rig HSE cases. The main recommendations are outlined below.

Compliance with a rig HSE case requires knowing its content. Since the majority of the staff stated that they had not read the complete HSE case document, it might be vital to simplify what is the minimum information that must be known; this can be done by various methods such as developing handbooks with essential information for the different departments, providing training to familiarise the staff with the content of the rig HSE case or establishing safety campaigns that would increase the staff's understanding of HSE case requirements; hence, it is recommended that the drilling contractor considers suitable means to acquaint the rig personnel with the required knowledge to be able to fulfil the HSE case obligations.

Overcoming the implementation gaps would facilitate the operationalisation of HSE cases. The majority of the respondents perceived that there were gaps between what was required in a rig HSE case and what was being implemented at the rig; hence, it is recommended that the company investigate and identify those gaps, and implement a strategic action plan to eliminate or reduce them. Some of the initiatives that might worth considerations are restructuring the HSE audit process to better utilise rig HSE cases, training roving HSE case coaches who can visit the rigs and enhance the level of understanding and compliance, and designing HSE campaigns that facilitate the implementation of rig HSE cases.

Using technology can make safety cases more effective. One of the modern initiatives that facilitate the operationalisation of safety cases is referred to as 'iSafetyCase' which is a web-based application that can effectively manage and enhance compliance with the requirements of a rig HSE case. The system is relatively easy to use and also provides supporting material to help with better understanding. It also enables a rig HSE case to be updated and approved with almost no cost (Environmental Resources Management, 2019).

11.2 Recommendations for Future Research Areas

Further research is recommended to ascertain the ability of HSE cases in reducing major accidents. As discussed earlier, it appears that none of the existing literature has managed to validate the effectiveness of safety cases evidently; hence, a thorough investigation may be required to determine the worthiness of safety cases; this might be of the essence for countries that intend to enact the safety case regime. Moreover, since the outcome of this study was based on data that had been obtained from one company that operated in a country where safety cases are considered best practice but not legally required, it would be beneficial to compare the effectiveness between a regulated safety case and a non-regulated safety case to attempt to quantify the merits. Thus, it is recommended that wider scope research is conducted to affirm the effectiveness of HSE cases.

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14 Appendices

Appendix-A: The research questionnaire

UNIVERSITY OF HULL The effectiveness of non-regulated HSE cases in the drilling industry

Welcome...
Thank you in advance for your participation. Your feedback is extremely important. Please go through the details below before granting your consent to participate.

The research topic background and aim:
In the oil & gas industry, safety cases were initially introduced, in the UK, following the Piper Alpha disaster in 1988. Safety cases were designed to reduce the risk of major accident hazards. Throughout the years, safety cases evolved to HSE cases. While in some countries the concept of an HSE case is embedded in legislation, in other countries, an HSE case is considered best practice.

In this study, we are attempting to determine the current effectiveness of the rigs' HSE cases. There are two specific objectives of this study: to find out the level of utilisation of the HSE case on the day-to-day running of drilling rigs, and to examine its ability in reducing the risk of actual and potential major accidents

An invitation to participate:
Approvals were obtained from the onshore and offshore operation managers for sending this questionnaire; however, please note that this research is for educational purposes only, and we can assure you that all responses will be completely anonymous and will not be used for any other purposes. Please do know that your responses are increasingly valuable to the research team, and we would greatly appreciate if you would answer all questions; However, if you feel that you do not want to answer a particular question, we will accept your decision.

The time commitment expected of participants:
We appreciate how busy you are; this is why the questionnaire was constructed to take no longer than 10 minutes.

For any inquiries or more details, the researcher's contact details are below:
Karim Ali
Karim_Ali_Yousef@yahoo.com
https://www.linkedin.com/in/karim-ali-ali/
+61414922810

Should you have any concerns about the conduct of this research project, please contact the Chemistry Ethics Officer:
Dr T. Horozov, School of Mathematics and Physical Sciences - Chemistry, University of Hull, Cottingham Road, Hull, HU6 7RX;
t.s.horozov@hull.ac.uk
+441482465220

Consent to participate, I understand that:

1. Upon receipt, my questionnaire will be coded and my identity will be kept separately from it.

2. Any information that I provide will not be made public in any form that could reveal my identity to an outside party i.e., that I will remain fully anonymous.

3. Aggregated results will be used for research purposes and may be reported in scientific and academic journals.

4. Individual results will not be released to any person except at my request and on my authorisation.

5. I am free to withdraw my consent at any time during the study in which event my participation in the research study will immediately cease and any information obtained from me will not be used.

* 1. Informed consent:

☐ By ticking this box, I hereby give my informed consent to participate.

UNIVERSITY OF HULL The effectiveness of non-regulated HSE cases in the drilling industry

* 1. What is your rig name?

- ○ GDI-1
- ○ GDI-2
- ○ GDI-3
- ○ GDI-4
- ○ GDI-5
- ○ GDI-6
- ○ GDI-7
- ○ GDI-8
- ○ Rig Alkhor
- ○ Rig Dukhan

2. The rig HSE case is an effective tool for preventing major accidents. To which degree do you agree or disagree with this statement?

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

3. Please explain your answers to the previous question
(Please provide as much details as you reasonably can: this will enable us to have better understanding and produce high-quality research)

4. How important is the HSE case to you?

- ◯ Important
- ◯ I am not sure
- ◯ Not important

5. How effectively the HSE case is being supervised at your rig?

6. Knowing that the cost of developing an HSE case is approximately 200,000 Qatari Riyals, If you move to another rig that doesn't have an HSE case, would you encourage the rig management to have an HSE case developed?

- ◯ Yes
- ◯ No

7. How frequently do you use the HSE case of your rig?

- ◯ Regularly - almost daily
- ◯ When needed - when I need to find a piece of information
- ◯ Other (please specify)
- ◯ I do not use the HSE Case .... (skip question 8 and go to question 9)

8. Which part of the HSE Case do you use the most?

- ◯ All of the HSE Case
- ◯ Bowties
- ◯ Risk register
- ◯ Other (please specify)
- ◯ HSE Critical tasks
- ◯ Matrix of permitted operations (MOPO)

9. Have you read the complete HSE case of your rig?

- ◯ Yes
- ◯ No

10. Please rank the tools below according to their effectiveness in reducing risks of major accidents. (1 being the most effective and 4 being the least effective)

- Rig HSE Case
- Rig specific Job Safety Analysis (JSA)
- Rig specific Emergency Response Procedure (ERP)
- Company risk register

11. How easy is it to implement the HSE case?

- Very easy
- Easy
- Neither easy nor difficult
- Difficult
- Very difficult

12. Do you feel that there are gaps between the HSE case requirements and what is being implemented at the rig?

- Yes
- No

13. Please explain your answers to the previous question

14. In your opinion, do we 'still need' or 'no longer need' HSE Cases in our drilling industry?

- Still need HSE Cases
- No longer need HSE Cases

15. Please explain your answers to the previous question
(Please provide as much details as you reasonably can: this will enable us to have better understanding and produce high-quality research)