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# Human Error Knowledge Management Framework in Major Hazard Accident Prevention

Ahmad Soyuti Sabran[1,*], Abdul Rahman Abdul Rahim[2], Sa'ardin Abdul Aziz[1], Roslina Mohammad[1]

[1] Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Kuala Lumpur 54100, Malaysia
[2] Industrial and Systems Engineering Research Group, Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Kuala Lumpur 54100, Malaysia

**ABSTRACT**

The purpose of this study was to investigate the need for Knowledge Management (KM) and its link with Human Error (HE) that leads to major hazard accidents with single or multiple fatalities. To date, the majority of major accidents were because HE is including those in the oil and gas industry, either at offshore or onshore worksites. The aim of this study was to develop a KM framework integrated with HE which can be used to prevent, minimise or reduce major accidents among the oil and gas industry players in offshore and onshore installations. Objective: The objectives of this study were (1) to determine the critical success factors for KM framework based on HE elements, (2) to develop and validate an integrated framework that integrates KM and HE to prevent major accidents and (3) to determine the HE factors that contribute to major hazard accidents. Based on the literature review, a research methodology for KM and HE in major accident prevention in oil and gas installations was developed. Besides, the most suitable types of KM, the effectiveness of KM in offshore installations and the best method of sharing the outcome from KM in oil and gas installations were also determined. Results: The results and findings of the analysis of the secondary data, the cross-sectional survey questionnaire and the interview data on the view of the Company and Contractors which were among the primary data of the research were presented. The relevant and related research questions were included in the questionnaire. The results and the conclusions were based on the analysis of the feedback from the selected respondents using Statistical Package for Social Science (SPSS) software. Conclusion: Possible result of developing KM framework implementation in OSH and integrating HE to prevent major accidents in oil and gas installations. The relationships between KM and HE that contributed to major accidents in the oil and gas industry and the elements of health and safety practices were examined in this study. The finding revealed that HE is the significant factor behind the major accidents in the installations at offshore facilities and the overall health and safety performance. Critical success factors such as organisation, leadership roles, transfer of knowledge, and learning and sharing in major accident prevention are more of an outcome of the relationship between HE and the major accidents in the oil and gas industry. On the other hand, lack of understanding, resistance to change and lack of management commitment within the organisation, especially the OSH management were identified as the barriers in implementing KM frameworks. Most of the barriers are well taken care of by the management to overcome and ensure the success of the implementation process in the company. Recommendations for future studies and the prevention methods to improve health and safety management in the oil and gas industry to improve safety and security in the workplace, either within or outside Malaysia, were included.

***Keywords:***
Knowledge Management framework; human error; oil and gas industry; major accident; occupational safety and health

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* *Corresponding author.*
*E-mail address: saa.kl@utm.my*

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## 1. Introduction

The challenges faced by the oil and gas industry contractor working in offshore construction, the need for Knowledge Management (KM), and its link with the Human Error (HE) led to a significant accident that caused single or multiple fatalities. The research aim, objectives, and scope are also discussed. Several methods and actions have been proposed in order to improve safety through establishing policies, guidelines, and strategies for the organization's operations for tracking and reporting on sustainable performance. However, some of the issues such as lack of KM in safety, reoccurring accidents, and no lessons learned database has contributed to the inconsistency trend of safety statistic. Action is needed in the oil and gas industry sector to prevent and eliminate injuries, health hazards, and property damage and conserve the environment to ensure consistency and synergy.

## 2. Objective

This research aims to develop a KM framework and link with HE, which can be used as a guide to prevent, minimize or reduce major accidents among oil and gas industry players in offshore and onshore installations. Objectively the research is to determine the HE factors that contribute to Major Hazard Accident (MHA) then the factors identified is use to determine the critical success factor (CSF) for KM framework based on HE elements. The findings are used to develop and validate an integrated framework integrating KM and HE to prevent major accidents.

## 3. Scope

This study focuses on developing KM related to HE minor accidents in oil and gas installations. Oil and gas industry players in this study refer to significant Oil and Gas companies and contractors. The scope of the research only covers oil and gas installation and exclude fabrication yard, HE aspects which result in accidents and KM framework proposed is not subjected to implementation

## 4. Literature review

### *A. Knowledge Management (KM)*

Knowledge Management (KM) is a concept in which an enterprise gathers, organizes, shares, and analyses individuals and groups' knowledge across the organization in ways that directly affect performance [33]. Meridith [18] stated that KM is how organizations generate value from intellectual and knowledge-based assets. KM involves identifying and analyzing available and required knowledge assets and processes to fulfill organizational objectives [43]. Robert [33] stated KM is simply the transfer of knowledge from one person to another, the result of which enables the recipient to benefit from the collected wisdom of the more experienced members of an organization or group.

Knowledge and information management are becoming essential for the upstream oil and gas industry. Core workers within the industry are likely to retire in the coming years, which, if not appropriately managed, could lead to a knowledge gap in the industry. Economic conditions remain challenging, meaning companies will have to explore ways to use their information to maximize their corporate returns. Developments within the industry following the Deepwater Horizon disaster are also likely to impact information and KM practices in the country. A report from Deepwater Horizon Joint Information Centre said that the response team is planning to use KM practices to improve the

Gulf of Mexico's safety for the upstream oil and gas industry. Oil and Gas IQ Report [25]. James [32] reported in the summary of BP's Deepwater Horizon following the Gulf of Mexico oil spill in 2010 and handed over $500 million to firms that suffered losses from the tragedy, which resulted in 11 deaths.

The research by EPU has also reported similar findings in which Malaysian organizations were lagging their foreign counterparts from leading economies. Wong and Aspinwall [48] introduced a framework for implementing KM in the SME sector, which is centered on six major themes: the types of knowledge to be managed, the socio-technical perspective of KM, the formation of a KM coordinating group, the initiatives to be implemented, a guide to deploying these initiatives, and the tools and techniques to support them.

Rusli *et al*., [2] stated that the KM framework is essential for the organizations that intend to implement KM as guidelines to avoid errors and benefits in terms of time and cost. In a recent Petronas-related incident, an oil tanker caught fire and exploded at Petronas Chemicals Methanol Sdn's jetty. Bhd. on July 26, 2012. The facility is part of the Rancha-Rancha industrial zone, located on Pulau Enoe, near Labuan, Koh [15]. The 38,000 deadweight-tonne MISC tanker was loading six methanol tonnes when a small fire broke out during a thunderstorm. Refer Figure 1 for Petronas Safety & Health Performance 2009-2012 [30]. Although Chih-Ping *et al*. [46] has conducted a review on KM frameworks, the cases used in the study were only based on highly knowledge-intensive companies. Therefore, KM performed in other industries such as the oil and gas industry that require good performance in terms of Occupational Safety and Health (OSH), especially to identify on Human Error (HE) are not studied.

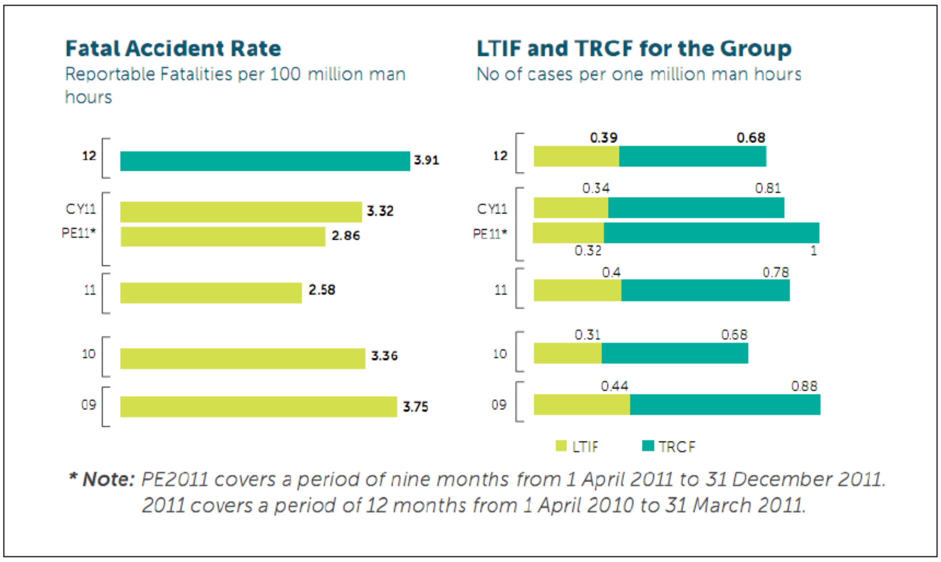


**Fig. 1.** Petronas Safety & Health Performance

### B. *Human Error (HE)*

Human Error (HE) means that something has been done that was "not intended by the actor; not desired by a set of rules or an external observer, or that led the task or system outside its acceptable limits." In short, it is a deviation from intention, expectation or desirability, [27]. According to Hollnagel [11], logically, human actions can fail to achieve their goal in two different ways: the actions can go as planned, but the plan can be inadequate (leading to mistakes); or, the plan can be satisfactory, but the performance can be deficient (leading to slips and lapses). However, Reason [31] believes that a mere failure is not an error if there had been no plan to accomplish something in particular. The human factors theory of accident causation attributes accidents to a chain of events ultimately caused by human error. It consists of three broad factors that lead to human error: overload, inappropriate response, and inappropriate activities (refer Figure 2), Accident Facts [3].

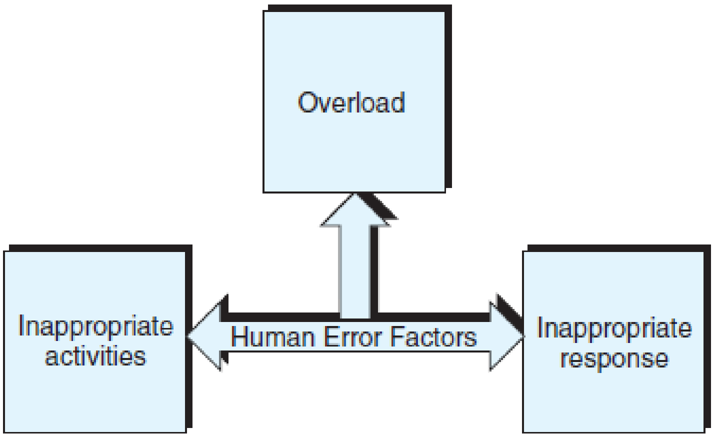


**Fig. 2.** Factors that cause human errors. Accident Facts [3]

Overload amounts to an imbalance between a person's capacity at any given time and the load that person is carrying in a given state. A person's capacity is the product of such factors as their natural ability, training, state of mind, fatigue, stress, and physical condition. Inappropriate Response and Incompatibility is how a person responds in a given situation can cause or prevent an accident. If a person detects a hazardous condition but does nothing to correct it, they have responded inappropriately. Human error can be the result of inappropriate activities. An example of an inappropriate activity is a person who undertakes a task that they do not know how to do.

### *C. Major Accident Hazard (MH)*

Major accident is defined as an occurrence including, in particular, a significant emission, fire, or explosion resulting from uncontrolled development in the course of industrial activity which lead to danger to persons, whether immediate or delayed or inside or outside the installation, or to the environment, and involving one or more hazardous substances, Occupational Safety and Health Act 1994, OSHA (Control of Industrial Major Accident Hazards) Regulations 1996.

Researchers' commonly used theories to define major accidents were Heinrich's Triangle Theory [9] and the Swiss Cheese Model. Both theories can be correlated with Maslow's Hierarchy of Need [19] to link with the major accident and HE. In the Swiss Cheese Model, an organization's defenses against failure are modeled as a series of barriers, represented as slices of cheese. The slices' holes represent weaknesses in the system's parts and are continually varying in size and position across the slices. The system produces failures when a hole in each slice momentarily aligns, permitting hazard passes through holes in all the slices, leading to a failure.

While the Heinrich Domino Theory of Multiple Accident Causation developed in 1931 by H. W. Heinrich; states that an accident is only one of a series of factors, each of which depends on a previous factor. According to Heinrich, there are five factors in the sequence of events leading up to an accident. These factors can be summarized as follows [3]. Heinrich's theory has two central points: the action of preceding factors causes (1) injuries and (2) removal of the central factor (unsafe act/hazardous condition) negates the action of the preceding factors and, in so doing, prevents accidents and injuries [3].

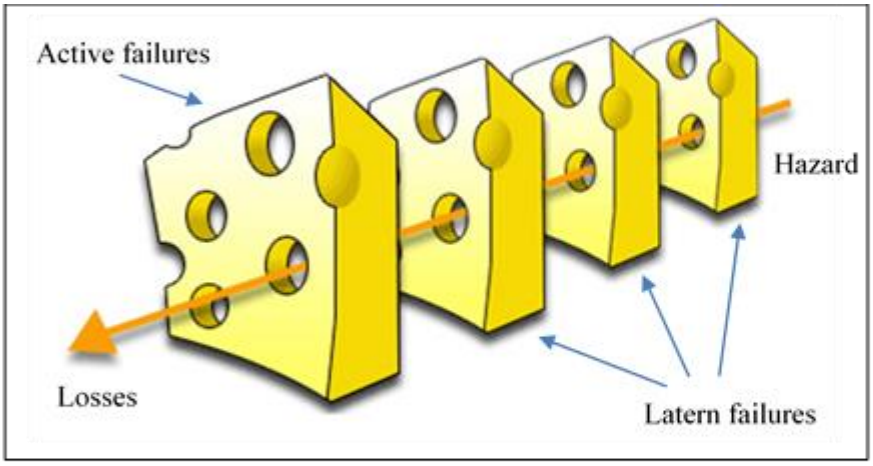


**Fig. 3.** Swiss Cheese model

The accident or incident theory is an extension of the human factor's theory. It was developed by Dan Petersen [29] and referred to as the Petersen accident/incident theory. Petersen introduced such new elements as ergonomic traps, the decision to err, and systems failures while retaining much of the human factor's theory. Petersen also highlighted that a variety of pressures such as deadlines, peer pressure, and budget factors could lead to unsafe behavior and systems failure is an essential contribution of Petersen's theory. Following are ways that systems can fail, according to Petersen's theory:

i. Management does not establish a comprehensive safety policy.
ii. Responsibility and authority concerning safety are not clearly defined.
iii. Safety procedures such as measurement, inspection, correction, and investigation are ignored or given insufficient attention.
iv. Employees do not receive a proper orientation.
v. Employees are not given enough safety training.

In conclusion, the researcher found a direct relationship between Peterson's theory and HE that can be linked to Maslow's Hierarchy of needs' safety aspect. First, overload shows the potential for a causal relationship between HE and safety (accident/incident). Second, system failure establishes management's role in accident prevention and the broader concepts (from the perspective of occupational safety in the workplace). Major Accident Worldwide, Karasek [14] stated that the top 10 significant accidents had had a significant influence on regulatory regimes and industry standards on risk management over the last century. Past studies have discovered, and investigations revealed, that majority of these incidents are caused by a combination of many factors whose roots can be found in the lack of HE factors (micro and macro ergonomics) considerations.

Meshkati [21] draws attention that HE and the resultant failures are both the attribute and effect of complicated operational processes, inadequate training, non-responsive organizational systems, non-adaptive organizational designs, haphazard response systems, and sudden environmental disturbances. This statement is in line with McKenzie [17], who suggested that HE is a symptom of underlying problems, not individuals who do not plan to make mistakes whereby they do what makes sense to them at the time of the accident. McKenzie [17] and Pate-Cornell [28] stated that HE and questionable decisions, flaws in the design guidelines and design practices (e.g., tight physical couplings or bad redundancies). It is misguided priorities in the management of the trade-off between productivity and safety and mistakes in the management of the personnel on board, and errors of judgment in the process by which financial pressures are applied on the production sector (i.e., the oil companies' definition of profit centers) resulting in deficiencies in inspection and maintenance operations. Appendix – 1, Shows a summary review of significant accidents in the oil and gas industry worldwide.

Major Accident in Malaysia, Some major accidents in Malaysia are Tiram Kimia Depot Chemical explosion (1992), Shell Bintulu explosion (1997), Petronas Gas Berhad fire and explosion (2002), Petronas LNG Complex Bintulu fire incident (2003), refinery fire in West Malaysia (1999) and the Fatty Chemicals methanol blast (2006), Petronas LNG Complex Bintulu gas leakage (2009), Shaluf and Ahmadun [35], mStar Online, [23] and the latest accident Petronas gas pipeline explosion located in between Lawas town and Long Sukang in the northernmost district of Sarawak (2014). Petronas experienced the worst ever group safety record, with 31 fatalities in 1998 followed by 13 and 17 fatalities in 1999 and 2000 respectively, all involving contractors. There were three fatalities and four major injuries involving contractors' workers in the Petronas Gas Berhad explosion in 2002 [36]. Two fatalities and two significant injuries involving contractors' workers in the Fatty Chemicals methanol blast in 2006.

Safety Performance Monitoring by Oil and Gas Players, indicators reveal a significant reduction in fatal accident rate over the past ten years worldwide. The 2011 edition of OGP's Safety and Health performance indicators showed that the fatal accident rate was down by 32% in 2011 compared with the previous year's performance. This was an actual reduction from 94 reported fatalities in 2010 to 65 reported fatalities in 2011. The number of working hours reported increased by 1% to 3,456 million works hours in 2011 [26].

However, in Malaysia, personal injury performance shows the lost time injury frequency has increased by 12%, and the total recordable injury rate is virtually unchanged in 2012 compared with the 2011 result. There was no specific study to focus on the significant accident link because HE in the oil and gas industry. Hwee [44] reported the loss due to a significant accident in the oil and gas industry could be huge as the contract value is worth RM10 billion for three years, which is equivalent to RM1 million loss in a day if an accident occurs. In the year 2013, a total of 63,557 accident cases were reported, an increase of 2,005 cases or 3.26% in comparison to 61,552 cases in 2012. Of these, 56.48% were industrial accidents, while 43.52% were related to commuting accidents. From all the accidents reported, it was found that industrial accidents and accidents while commuting about his employment showed an increase in comparison to 2012 [38].

Major Accident Hazard Review, the researcher's review to understand the gap between KM and HE that link to the major accident, which some of it explained in an earlier section in this paper. An issue was not addressed, such as the link between KM and HE that led to significant oil and gas industry accidents.

Major Hazard Installation, which is the causal factor of a significant accident, can be categorized in three main sections: Human Related Error, Mechanical or Equipment Related Error, and Other Factor Error. More than ten significant hazard installation occurrences worldwide and in the domestic incident have been identified.

### *D. Unsafe Act and Decision to Err*

Aksorn and Hadikusumo [5] stated that workers' unsafe acts are considered significant contributors to work-related accidents and injuries on construction sites. However, not much work has been done to address why unsafe acts of workers occur, particularly in the construction industry. This study found that the top three most frequent unsafe acts are statistically associated with several decision-to-err factors, including lack of management support, management pressure, group norms, overconfidence, discomfort, experience, and laziness.

For many years, safety practitioners have addressed physical preventive measures such as machine guarding, housekeeping and inspection, since poor physical conditions cause accidents. However, not much preventive work has been done on the human aspects. The fact that many researchers believe that unsafe acts of workers are the major contributors of accidents and injuries, rather than poor working conditions, e.g., Sawacha *et al*., [34], Abdelhamid and Everett [1], Stranks [41], Haupt [8]. Holt [10] suggested that there is the need for a change of direction in construction safety research to identify the possible influential factors of workers' decisions.

As far as HE is concerned, this research also considered investigating the relationship between the decision-to-err factors and the unsafe acts. This relationship is essential for management to study what unsafe acts could occur on the site, determine what decision-to-err factors might contribute to these unsafe acts, and develop solutions that could reduce unsafe acts.

Generally, accidents at work occur either due to unsafe working conditions or unsafe worker acts. In construction, it is suggested that unsafe act is the most significant factor in the cause of site accident Sawacha *et al*., [34], Abdelhamid and Everett [1]. There is no general agreement on the definition of an unsafe act.

However, it has been defined in a similar focus on unaccepted practices that can produce future accidents and injuries. For example, Stranks [41] defined an unsafe act as any act that deviates from the generally recognized safe way of doing a job and increases the likelihood of an accident. Several unsafe acts have been identified by many researchers such as Petersen [29], Stranks ([41], Simachokdee [37], Michuad [22], Abdelhamid, and Everett [1] and Holt [10]. Table 1 shows the identification of unsafe acts, and it is proposed by Thanet Aksorn and Hadikusumo [5]. A similar table is widely used in the construction industry, including the oil and gas sector, in promoting safety programs such as the Unsafe Act and Unsafe Condition (UAUC). Some of these unsafe acts are:

(1) Working without authority on the job can cause accidents since unauthorized workers may lack the necessary skills or unfamiliar with the job process.

(2) Failure to warn or secure members out of danger is considered unsafe since many accidents occur because workers pay less attention to a warning or secure co-workers working under conditions with a high probability of accident occurrence.

Working at improper speeds, exceeding the prescribed speed limits, or unsafe speed actions could cause accidents, e.g., workers who handle objects quickly could slip and be injured.

### *E. Major Accident Hazard Review*

The researcher's review to understand the gap between KM and HE that links to significant accidents are explained in this chapter's earlier section. An issue that did not address KM and HE is link led to significant oil and gas industry accidents.

HE factors have contributed to the significant accidents or disasters such as the Chernobyl disaster identified by Stang [40], fire and explosion at Bright Sparklers in Sungai Buloh by Shaluf *et al*., [36], Piper Alpha disaster (explosion) by Pate-Cornell [28], Bhopal disaster by Peterson [29], Deepwater Horizon blowout BOEMRE (2011).

The literature reviewed show that the significant installation hazard most common item linked to human error. They are names such as inadequate supervision & planning, poor communication, fatigue, workload, training and competency, experience or expertise, familiarisation, memory, stress, drug, and alcohol influence.

*F. Review Summary*

Pate-Cornell [28] found that the HE factors contributing to the Piper Alpha disaster include inadequate supervision and planning, poor communication, relevant training and competency/expertise, failure to follow procedure, lack of awareness, unsafe acts, or negligence, and failure to observe warning signage of safety devices.

Coil et al. [3] stated that besides all factors stated by Pate-Cornell [28] in the Piper Alpha disaster also found additional HE factors such as fatigue, workload (overload), memory, and influence of drug and alcohol has contributed to the Exxon Valdez oil spill disaster. The same factors also found by the Shell investigation team (2011) in a fatal accident on-board pipelay barge at Batam field and a fatal incident hit by a watertight door in 2013.

A significant accident's causal factors can be categorized in three main sections: Human Related Error, Mechanical or Equipment Related Error, and Other Factor Error. There are more than ten significant hazard installation occurrences over the world and as well as in domestic incident has been identified.

To achieve the study's objective, the researcher will further investigate the relationship between the KM factors and HE and determine what HE factors might contribute to the major accident such as unsafe acts and decision-to-err factors as discussed in item D considering all literature review compilation in this section is.

## 5. Methodology

The research commended by reviewing the relevant literature review on construction safety aspects and conducting exploratory interviews with 15-20 construction crew (offshore workers) to obtain variables related to unsafe acts and decision-to-err factors.

*A. Questionnaire Validation*

Before including them in the questionnaire, the defined variables were validated by a panel of 20 construction safety experts. In this study, construction safety experts are defined as Senior Safety Managers, Safety Engineers, and senior safety officers involved in managing safety in offshore construction projects for at least eight years. The experts were asked to indicate the degree of agreement (i.e., 1 = disagree, 2 = somewhat agree, 3 = moderately agree, and 4 = strongly agree) for a set of defined variables whether they are applicable to be used as unsafe act variables and decision-to-err variables. A variable was considered applicable if the mean value is more significant than three or moderately agree in the measurement scale and the standard deviation (SD) is less than 1.00.

A first draft of the questionnaire was designed by incorporating those validated variables and disseminating it to a few respondents for the pilot test. The pilot test's purpose was to check the questionnaire's appropriateness, such as wording, instruction, measurement scale, and layout. Certain modifications were made to the pilot study, and a questionnaire was then finalized.

*B. Survey Form*

The survey form for this research is simple and divided into four main sections as follow:

i. Section A : Background of the respondent
ii. Section B : Human Error factors (Unsafe Act and Decision-to-Err);
iii. Section C : Factors that influence Human Error (Unsafe Act); and

iv. Section D : Open question reasons for factors that influence Human Error.

### C. Worksite

In actual data collection, the questionnaire survey was carried out on offshore construction projects on board at the main work barge, and SapuraKencana 2000 was chosen as a worksite for the study, which accommodated with more than 270 offshore workers at one particular time with continuously on project execution phase (in operations for a minimum of three months) in the year 2015 to enhance accuracy and the level of reliability of the research.

The target respondents, offshore construction workers, accidental sampling was preferable due to time limitation at the construction site. A face-to-face questionnaire cum interview was used to ensure a high response rate and undistorted information. Jaselskis and Suazo [12] proposed that face-to-face interviews could prevent interviewees from misunderstanding the questions, thus ensuring the data's accuracy and avoiding embarrassment to illiterate workers. In total, 143 workers have participated in the survey out of 200 issued survey forms.

### D. Interview Session

Several interview sessions were conducted depending on the target group of workers and working hours. During the interviews, the researcher read out all the questions and marked the scores as rated by the respondents. The questions had to be read out to the respondents because the offshore workers usually have a minimum understanding of this kind of survey. As a result, a total of 143 offshore workers (various disciplines/tasks) from 290 including executive (profession as engineers and above to represents management) and offshore construction crew (profession as supervisors and below to represent employees). During the offshore operations period, execution projects were individually interviewed, and questions on all unsafe acts were put to each worker to determine the frequency at which he has committed them.

For each unsafe act, a worker had to indicate the degree of influence for the 20 decision-to-err factors. This would require each worker to answer the questionnaire, taking about one and half an hour and two hours to complete. To reduce the survey's lengths, the questionnaire structure was rearranged to make it easier for the workers to answer the questions by using two-three forced-choice items. By this method, a worker had to choose only the first two or three unsafe acts he mostly committed and indicated the degree of influence of decision-to-err factors for the selected two or three unsafe acts.

By applying the forced-choice technique, the researchers could interview an offshore worker within 15 to 20 minutes, and thus, more data could be collected to enhance the reliability of the findings. To investigate the unsafe acts, the 143 offshore workers were asked to rate scores to indicate the frequency of the unsafe acts they commit on the construction site where they were then engaged.

### E. Data Analysis

It should be noted that when selecting a data analysis technique, a researcher should make sure that the assumptions related to the technique are satisfied (i.e., normal distribution, independence among observations, linearity, and lack of multi-collinearity between the independent variables. Analysis of interview data commenced after interview notes, and tape-recorded interviews were fully transcribed. First, for each of the 20 variables (Section B) of HE factors (unsafe acts), an interview question probed the complexity and range of activities. Second, for 24 variables (Section C), a further question probed the variable's perceived importance for a factor that influenced HE.

## 5. Results

Apart from being a valuable reference for future research on health and safety in the same setting, significantly for HE prevention minor accidents, the proposed operational framework contributes to understanding health and safety management in the oil and gas Exploration and Production (EP) and Transporation and Installation (TI) at offshore facilities whole. It highlights the need to create enabling conditions by reinforcing aspects of the HE prevention methods and techniques in the EP and TI sectors, favoring the overall health and safety management performance in the Oil and Gas Industry (OGI) while taking necessary steps to overcome barriers to managing health and safety effectively. The outcome of this is a HE KM framework for paramount accident prevention in EP and TI offshore facilities in Malaysia, as illustrated in Figure 4.

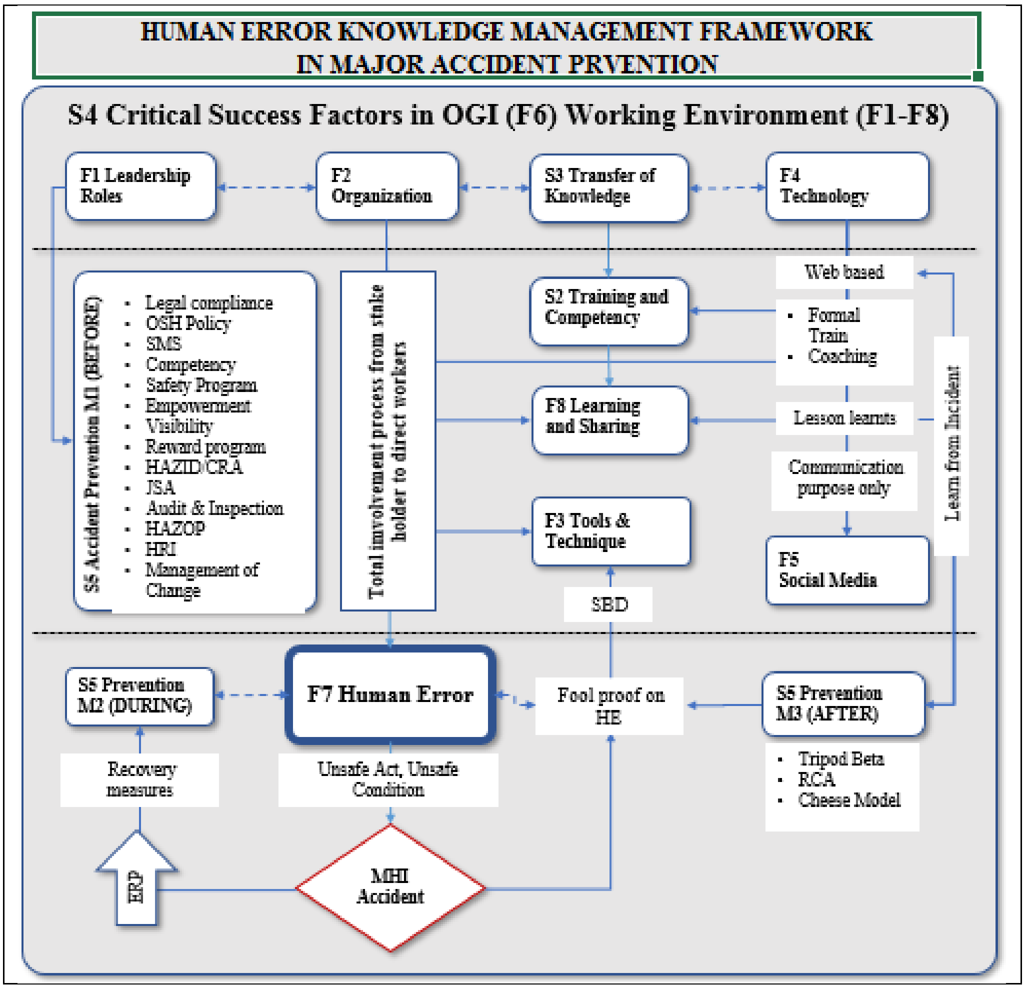


**Fig. 4.** Operational HE KM framework for significant accident prevention

The Operational HE KM can be implemented as illustrated in Figure 5.

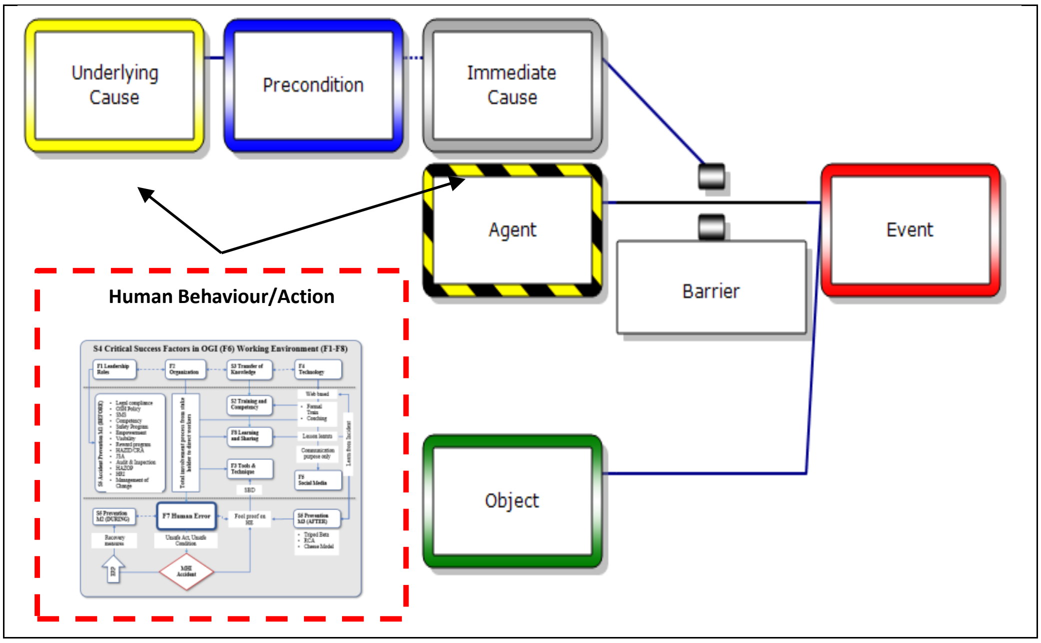


**Fig. 5.** Implemented of Operational HE KM

The operational HE KM in effective accident prevention programs and strategy should evolve through periodic review to meet the changing demands in response to an organization's internal and external influences, especially in the OGI. This adaptive approach will ensure the organization is changing demands to be factored into the newly introduced HE KM framework program's desired maturity level. According to Firestone [7], the operational framework may be validated through any following interactions internal organizational sources, interpersonal peer communications, interpersonal expert communications, meetings, e-mail messages, web documents, web-accessed databases, non-web accessed databases, web-enabled collaborative applications, media (CDs, Tapes) and printed documents.

## 6. Conclusion

This research aimed to develop a KM framework that is correlated to HE which can serve as a guide to avert or minimise major accidents among the OGI players in offshore and onshore installations within the Malaysia waters. The analysis of the CSF revealed the significant influence of all eight CSF elements. Significant CSFs which were under the leadership roles and organisations were poor supervision and planning, poor communication, lack of relevant training and competency or expertise, failure to follow procedure, lack of awareness, unsafe acts or negligence and failure to observe warning signage of safety devices. The unsafe acts of workers were deemed as the main contributor to work-related accidents and injuries in the high-risk offshore working environment. Sharing and learning with lessons learnt session was revealed as the most effective method to ensure that HE can be prevented where incidents or project lessons learnt issues are discussed thoroughly during the session (including common issues like what when well, what when wrong, causes and impact, and preventive measures for future reference). The consolidation of the major accidents reported and investigated revealed that most of the incidents were due to a combination of matters which could be traced back to HE. HE is responsible for up to 90% of workplace accidents, it is critical for any businesses, no matter what industry, to prevent these errors by any means necessary. In order to tackle this studied considered methods of HE prevention which include actions before-during-after the incidents or accident at the worksite. The study showed that the implementation of this operational framework will benefit EPs and TIs by increasing customer satisfactions, reducing the number of major accident due to human error as causal factor, reducing customer complaint, improving safety program and safety culture that emphasize on accident prevention as well as the total involvement from employee and partnership with suppliers or subcontractors in safety initiatives program.

The final integrated KM framework (Figure 4) of the OGI have been established and this research has produced results that validate the expectation from the implementation of integrated framework within EP and TI contractors and subcontractors. This framework highlighted fours main subjects, namely leadership roles, organisation, transfer knowledge and technology that integrated with key elements. The key importance of this framework is the total involvement from the stakeholder to the direct workers to ensure all elements can be worked out to prevent HE in MHI accidents

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