



Identification of Potential Risks and Controlling Factors Associated with Helicopter Operation: A Mix-Method Investigation from Oil and Gas Industries

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Abstract: This research article focuses on the identification of the characteristics of potential hazards and their suitable controlling factors for offshore helicopter operation at Malaysia and Saudi Arabia oil and gas drilling domains. In this study explanatory (Quantitative Leading to Qualitative) research design has been used for data collection and analysis process. While, 160 respondents for quantitative and 06 respondents for qualitative research has been participated in this study from targeted industries of Malaysia and Saudi Arabia. Likewise, descriptive statistical approach (Mean, Standard Deviation and Percentage) has been adapted for quantitative study and thematic analysis method has been used for qualitative part of this research. According to the descriptive statistical findings, respondents from Malaysian and Saudi Arabian oil and Gas industries are mutually considered Mechanical failure; Bad weather condition and pilot mistake are the major cause of offshore helicopter accidents with overall mean range 3.48 from Malaysia and 3.43 from Saudi Arabian respondent. Similarly, from qualitative results, respondent have highlighted mechanical and environmental hazard characteristics as a major cause of life-threatening accidents and injuries during offshore helicopter operation at targeted industries. Whereas, respondents from targeted industries highlights engineering and administrative controls as highly effective mitigating strategy to overcome potential hazards associated with helicopter operation.

Keywords: Drilling operation, oil and gas, helicopter operation, potential hazards, potential risk

1. Introduction

According to centre of disease control and prevention (CDC), offshore oil and gas drilling industries are seven times deadlier than the rest of all manufacturing and production industries [1]-[5]. Several operations are involved in offshore extraction process, but helicopter operation is one of the major operations at offshore oil and gas drilling sites which starts from rig assembling until the final production activities [2], [6]. As per the statistical data from year 2003-2010, helicopter crashes caused 75 % of all transportation related oil and gas drilling crew fatalities. There are several unexpected and unpredictable hazards are involved during transportation of drilling crew from offshore to onshore sites [2], [7].

Numerous technical and safety concerns have been reported by previous researchers such as lack of maintenance, difficulty in landing at offshore due to bad weather and human error [1], [8]. These potential hazards can be eliminated and reduced through implying sufficient hazard identification approaches and techniques [2], [9]. Similarly, through recognizing the potential hazards which are associated with helicopter operation the severity of accidents can be minimized by adopting suitable controls for particular activities [10], [11]. Consequently, this paper also focusses on the identification of nature and potential hazards characteristics and their suitable controls related to helicopter operation at Malaysian and Saudi Arabian oil and gas drilling sites through explanatory research design.

Oil and gas offshore drilling operations are one of the most hazardous jobs in the world [2], [14]. Every year, hundreds of people have been critically injured and several have been died during offshore oil and gas extraction activities [3], [4]. According to Offshore Energy report September (2016), four drilling crews were died and two were missed after a helicopter bound for a Chevron offshore platform in Angola crashed. From year 1983–2009, the National Transportation Safety Board (NTSB) database recorded a total of 178 helicopter crashes associated to oil and gas operations with an average of 6.6 crashes per annum. The crashes resulted in a total of 139 fatalities, including 41 pilots [4], [15].

Thus, there is a sheer need of the effective approach for the identification of characteristics and nature of potential hazards and their suitable controls correlated with helicopter operation at offshore drilling sites [2], [5]. Likewise, there is also a requirement for pooling of data from different oil and gas industries for controlling or minimizing the rate of injuries and accidents in effectual way [2], [12]. Therefore, this paper illustrates about the characteristics and nature of potential hazards and their suitable controls related with helicopter operation by adopting mix method data analysis approach for Malaysian and Saudi Arabian oil and gas industries. The outcome of this paper will help and facilitated the safety and health professionals or practitioners to avoid such potentially hazardous activities or events with suitable emergency or action plan prior to helicopter operation. This study seeks to achieve the following research objectives to solve above mentioned problems: (i) To classify the nature of helicopter operation during offshore drilling process among Malaysian and Saudi Arabian oil and gas industries, and (ii) To examine the characteristics of related potential hazards and their suitable controls associated with the helicopter operation at Malaysian and Saudi Arabian oil and gas industries.

2. Methodology

In this sequential explanatory research design, approximate population of 100 drilling crew has been considered in this study from each targeted country. While, sample size of eighty (80) oil and gas drilling crew members have been chosen through random sampling approach based on Morgan table of sample size from two targeted oil and gas industries from Malaysia and Saudi Arabia (names have been kept confidential) for quantitative research (Survey instrument). The sample size of respondents of this study are shown in Table 1.

The quantitative research instrument has been developed based on the oil and gas drilling activities standardized by OSHA USA with the Likert scale of five. Whereas, for the qualitative research analysis, a total of three (03) health and safety drilling professional experts from each country have been conveniently (through convenient sampling approach based on the availability of respondents) selected for in-depth semi structured interview from each focused industry. For the detailed analysis of quantitative data, descriptive statistical technique (Mean, Standard deviation and Percentage) has been employed through statistical package of social sciences SPSS.22. Whereas, for the interpretation of qualitative research, thematic analysis method has been used for analysing the characteristics of the most common potential hazards during helicopter operation.

2.1 Thematic Analysis Approach

Thematic data analysis is a most convenient and effective qualitative data analysis approach for the detailed transcription and data categorization [2]. It is suitable to all approaches involving qualitative methodology. In this approach, themes have been developed based on specified codes. Although, the coding indicates the categorization of transcribed data collected during interview sessions. In this study the gathered data from interview sessions for the identification of potential hazards associated with drilling operations with their most effectual hazard controls and measures has been categorized by using following steps for thematic analysis [3].

- Firstly, after transcription of interviews read the participants feedback on the asked query again and again for proper understanding.
- Secondly, once have indicated all the patterns from transcribed interviews start to create main themes or categorize.

- Finally, refer to all main themes and indicate sub themes between those main themes for supporting research findings. Further you can compare those themes based on respondents working domains, working experience, industrial location etc.

2.2 What-If Analysis Approach

What-If analysis approach has been employed in this study for the identification of potential hazards along with their effective and suitable hazard controls to eliminate and reduce the workplace risks at Malaysian, and Saudi Arabian onshore and offshore oil and gas industries during drilling operations. This approach is considered as one of the most advanced and effectual qualitative assessment for the identification of problematic industrial operations and their preventive controls [4]. Additionally, the flexibility of the What-If Analysis approach can be applied to nearly any industrial operation, process or activity, either existing or planned [3]. Moreover, it can be successfully applied to the routine and non-routine activities, equipment maintenance and service works [3-4].

Table 1 - Study participants

Country/Industry	No of Respondent	
	Quantitative	Qualitative
Malaysia	80	03
Saudi Arabia	80	03
Total	160	06

3. Quantitative Findings

To answer the first and second research objectives descriptive statistical research approach has been adopted for the identification of hazards and their suitable controls of helicopter operation among offshore oil and gas industries in Malaysia and Saudi Arabia. Consequently, for the validation of results and findings a table of specifications is adapted from Landlell 1997 as shown in Table 2. This table of specification has been used to measure the nature of hazardous activities based on the level of mean range [16].

Table 2 - Level of hazardousness

Category	Mean	Hazardousness
1	1.00-2.33	Lo
2	2.34-.3.67	Moderate
3	3.68-5.00	High

According to the response from drilling crew and health and safety professionals from Malaysian oil and gas industry as shown in Table 3, during helicopter operation mechanical hazards and pilot error is considered as one major hazardous factors and cause of accident which are under moderate level of mean range which as indicated in Table 2. Likewise, response from Saudi Arabian oil and gas industries considered that the bad weather during helicopter activity and also pilot error with low competence in handling aircraft are cause of major injuries which are leading to death and life time disabilities which are also under moderate range of mean score.

Table 3 - Mean and standard deviation score for on and offshore rig assembling operation

Items Helicopter Operations	Malaysia		Saudi Arabia	
	Offshore	Offshore	Offshore	Offshore
Mechanical Hazards during helicopter operation at offshore drilling operation?	3.5	.59	3.40	.67
Bad weather is hazardous factor of helicopter accidents?	3.4	.49	3.42	.67
Pilot mistake is the hazardous factor and cause of offshore helicopter accidents?	3.5	.50	3.47	.64
Total	3.4	.53	3.43	.66

3.1 Potential Hazard associated with Helicopter Operation

Table 4 specified the Frequency (f) and Percentage (%) of potential hazard associated with helicopter operation at Malaysian and Saudi Arabian oil and gas industries. According to the descriptive findings 50% respondent from Malaysian oil and gas industry and 28% from Saudi Arabian oil and gas industry highlighted mechanical hazards as

potential hazards during helicopter operation. Similarly, 50% of them from Malaysian and 72% from Saudi Arabian oil and gas industries specified that the environmental hazards are highly contribute for unexpected accidents at offshore drilling sites.

Table 4 - Hazard associated with offshore helicopter operation (N = 40 each domain)

Potential Hazards	Malaysia	Saudi Arabia
	Offshore	Offshore
Mechanical Hazard	50 %	28%
Environmental Hazard	50%	72%
Total	100%	100%

3.2 Identification of Effective Hazard Controls Related with Helicopter Operation

In the context of helicopter operation, the suitable hazard controlling strategies for accident prevention at offshore drilling domains based on the Frequency (*f*) and Percentage (%) as depicted from Table 5.

Table 5 - Quantitative findings of effective hazard controls for helicopter operation (N = 40 each domain)

Effective Hazard Controls	Malaysia		Saudi Arabia	
	Offshore		Offshore	
	%	<i>f</i>	%	<i>f</i>
Engineering	2	0	27	11
Administrative	5	2	38	15
P	2	1	35	14
P	5	0		
Tot	10	4	100	40
al	0	0		

20% respondents from Malaysian oil and gas field, 27% from Saudi Arabian offshore sites specified engineering controls as most effective for accident prevention during helicopter operation as shown in Table 5. While, 55% participants from Malaysian drilling domain and 38% from Saudi Arabian petrochemical drilling sites specified administrative hazard controls and measures as more sufficient for the elimination of potential hazards. Correspondingly, for Personal Protective Equipment (PPE) controls, 25% from Malaysian offshore sites and 35% from Saudi Arabian drilling domain indicated them as suitable and for overcoming the life-threatening events during helicopter operation.

4. Qualitative Findings

In order to analyze the perception of health and safety drilling professionals regarding potential hazards which occur mostly during helicopter operation and their suitable controls at offshore drilling sites semi-structured interview has been conducted. For the analysis of qualitative data, thematic analysis approach has been implemented for semi structure interviews from targeted respondents by assigning code numbers (MY-Malaysia and SA-Saudi Arabia) for recognizing their industries, as shown in Table 6.

Table 6 - Respondents interview code

S.NO	Malaysia	Saudi Arabia
1	MY01	S
2	MY02	S
3	MY03	SA3

4.1 Environmental Hazard associated with Helicopter Operation

In the perception of potential hazards during helicopter operation at offshore drilling activities, participants from Malaysia and Saudi Arabia has mostly emphasized on bad weather as one of the causes of majority of accidents in the offshore drilling sites as shown in Fig. 1. Likewise, participant SA2 from Saudi Arabian offshore oil and gas industry also informed about the statistics of helicopter accidents accounted for 128 fatalities from 2007-2012, making up 75 percent of all transportation related deaths for oil and gas workers mostly due to unconditional and bad weather during offshore landing. Similarly, participant MY1 from Malaysia also directed that the helicopter operation during heavy weather is hazardous; therefore, if there is no emergency then safety professionals and management stop the transportation process immediately during this scenario.

4.2 Mechanical Hazard associated with Helicopter Operation

Correspondingly, helideck structure damage and failure has also specified as reason of accidents as participants mentioned during interview sessions from targeted industries. Response from Participant MY1 from Malaysia and SA2 from Saudi Arabia have reflected that the damaged helideck can also make problems during landing on offshore rig site and high possibility to damage helicopter parts and injured passengers as well.

4.3 Human Hazard associated with Helicopter Operation

Lastly, respondent from Malaysian and Saudi Arabian offshore drilling industry also recognized unprofessional flying crew as one of the potential hazards which can also lead to unsuccessful landing and helicopter crash in sea during landing procedures. According to the interview, participant MY3 from Malaysia and SA1 from Saudi Arabia emphasized that pilot error is also cause of accidents, if flying crew is not fully aware about the helicopter emergency plans during aircraft engine failure as shown in Fig. 1. Therefore, pilot should have broad safety and technical knowledge before dealing with this risky operation.

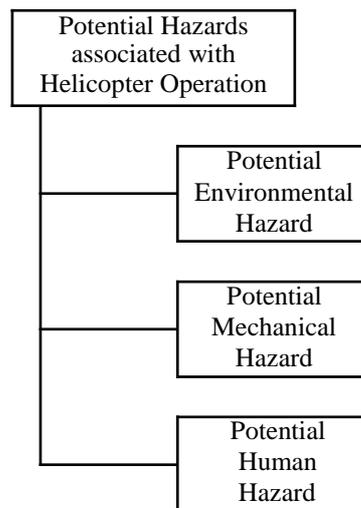


Fig. 1 - Potential hazards associated with helicopter operation

4.4 Identification of Potential Hazards and Effective Hazard Control Related with Helicopter Operation

The helicopter operation is also an alternative and effective way for transporting drilling personnel’s and goods from land to the offshore platforms. While, helicopter operation is some time highly dangerous during bad weather. There are several accidents and fatalities happened during helicopter operation in past years due to engine failure, stormy weather and sudden fire. In this study, the qualitative findings for the identification of potential hazards associated with helicopter operation along with their suitable hazards controls at targeted oil and gas industries are specified in this section.

5.4.1 Environmental and Safety Hazards with Helicopter Operation

The interview participants of this study indicated environmental and safety hazards as potential hazards associated with helicopter operation are specified below and illustrated in Table 7.

Table 7 - Hazards associated with for Helicopter Operation

Malaysia Offshore Hazard		Saudi Arabia Offshore Hazard	
	Code		Code
Helideck structural failure and pilot mistake	MY1	Pilot error and weather	SA1
Windy and stormy weather	MY2	Equipment failure	SA2
Unprofessional pilot and crew	MY3	Bad weather and helideck hazards	SA3

- Heavy wind: In the perception of potential hazards during helicopter operation at offshore drilling activities, participants from Malaysia and Saudi Arabia has mostly emphasized on bad weather as one of the causes of majority of accidents in the offshore drilling industry. Participant SA2 from Saudi Arabia also informed about the statistics of helicopter accidents accounted for 128 fatalities from 2007-2012, making up 75 percent of all transportation related deaths for oil and gas workers mostly due to unconditional and bad weather during offshore landing.

Similarly, participant SA1 from Saudi Arabia also directed that helicopter operation during heavy weather is hazardous, there for if there is no emergency then safety professionals and management stop the transportation process.

- Helideck structural failure: The helideck structure damage and failure has also specified as reason of accidents as participants mentioned during interview sessions from targeted industries. Response from Participant MY1 from Malaysia and SA3 from Saudi Arabia have reflected that the damaged helideck can also make problems during landing on offshore rig and possibility to damage helicopter and injured passengers as well.
- Pilot error: Finally, in helicopter operation, respondent from Malaysia and Saudi Arabia also recognized unprofessional flying crew as one of the potential hazards which can also lead to unsuccessful landing and helicopter crash in sea during landing procedures. According to the interview participant, MY3 from Malaysia and SA1 from Saudi Arabia emphasized that pilot error is also cause of accidents, if pilot do not know about helicopter emergency plans during engine and aircraft engine failure. Therefore, pilot should have broad safety and technical knowledge.

4.5 Effective Hazard Controlling Factors and Measures for Helicopter Operation

4.5.1 Engineering and Administrative Control for Heavy Weather

- Job safety analysis (JSA) for helicopter operation: As participant MY2 from Malaysian offshore industry stated that hazards related to heavy weather can avoided and controlled by conducting job safety analysis for helicopter operation. Similarly, the heavy weather hazard can be minimize based on all possible consequences related to weather and plane actions according to the authorized weather forecast reports to prevent deaths and injuries.
- Installation of weather forecast instrument on rig: Participant SA1 and SA3 have point of agreement on the installation of rig forecast information instrument or system on operational rig for helicopter operation itself from drilling platform to update weather updates before flying from offshore platform to onshore destination or both sides.
- Helicopter crash rescue training and emergency planning: In the context of Saudi Arabian and Malaysian oil and gas industry, participant and MY2 and SA1 have argued that the unconditional weather hazards can be eliminated through developing emergency and action plans. They have mentioned that, due to the nature of this operation most of the time weather forecast is not completely reliable. Because, natural disasters cannot be controlled, therefore all crew member should be trained enough for rescue operation to survive in case of offshore helicopter crash accident.

5.5.2 Administrative Control for Helideck Structural Failure

- Landing Communications: To avoid helideck structural failure hazards, participant MY1 have suggested that, before landing on an offshore helideck, pilots are encouraged to establish communications with the officials they are operating the helideck and drilling rig to get the clearance prior to landing. Further, they will inspect and examine the helideck condition and will allow them for safe and secure landing.
- Three Foot Parking Distance from Deck Edge: Participant SA3 from Saudi Arabian oil and gas industry have highlighted that, the Helicopters operating on an offshore helideck land or park the helicopter with a skid or wheel assembly no closer than 3 feet from helideck edge because it will prevent the helideck to damage and also for the safety of pilot and helicopter itself.
- Visibility of Helideck Weight Limitation: In the context of Saudi Arabian and Malaysian oil and gas industry, Participant MY3 and SA2 has suggested that, the helideck weight limitations should be displayed by markings visible to the pilot. Because if the helicopter is overloaded then pilot will safety dropped the flight crew members or workers through rescue robe on helideck and then request for landing when weight limitation is under the range on helideck for avoiding the helideck collapse accidents.

5.5.3 Administrative Control for Pilot Error

- Competent and efficient pilot and crew: Conferring to the interview response from participant MY3 from Malaysian oil and gas industry have recommended that the competencies of pilot for making good judgments and decisions in difficult scenarios and able to communicate effectively with others crew members will be highly contribute for eliminating hazards due to unprofessional flying crew.
- Trained and experienced Pilot: Respondent SA1 from Saudi Arabian offshore oil and gas industry recommended on the query regarding suitable control for pilot error in helicopter operation that it can be reduced by assigning experienced and internationally well-trained pilot and crew members, they have broad legal and technical knowledge for helicopter operation.
- Maintenance and mechanics: Participant SA2 have reported and suggested that for controlling helicopter crash accidents offshore facilities providers and avionics engineers should follow up for overall maintenance of helicopter and evaluate the performance of the equipment in cockpit and Radio Frequency transmission system before and during flight.

6. Discussion

The helicopter operation which is consider as foremost oil and gas drilling crew transportation operation to offshore drilling sites [2]. According to findings based on survey instrument of this research, respondents of this study have highlighted environmental and safety hazards as a leading cause of critical injuries and on spot fatalities at Malaysian and Saudi Arabian offshore drilling domains. Hence, oil and gas drilling safety and health experts have specified in the regard of potential hazards associated with helicopter operation that the heavy wind due to stormy weather and Helideck structural failure because of the lack of proper maintenance has potential source of accidents at offshore oil and gas drilling platforms at targeted industries as shown in Fig. 2. Whereas experts highlighted that to overcome such potential hazards then engineering and administrative controls are effective and can utilized for accident prevention.

Furthermore, in the context of helicopter operation in the offshore oil and gas perspective highlighted the practicing of job safety analysis (JSA) by the field experts or safety supervisors prior to the helicopter operation in case of stormy and heavy wind [2]. While, in this scenario the engineering control by installing weather forecast instrument at offshore drilling rig has considered as more reliable and effectual. On the other hand, helicopter crash rescue training and emergency planning has been indicated as suitable hazard control based on offshore drilling safety professionals for dealing with extremely bad weather during helicopter operation [1]. Whereas, for helicopter structural failure the findings indicated that the administrative controls are most counselled as more effective and suitable like landing communications between sources, Three (03) foot parking distance from deck edge during landing and visibility of helideck with weight limitations [3]. Lastly, to overcome the human error during helicopter operation which has reported as most challenging and unpredictable industrial hazard can be effectually reduced through administrative approaches though enhancing the competency of pilots and providing them efficient training resources from expert trainers [4].

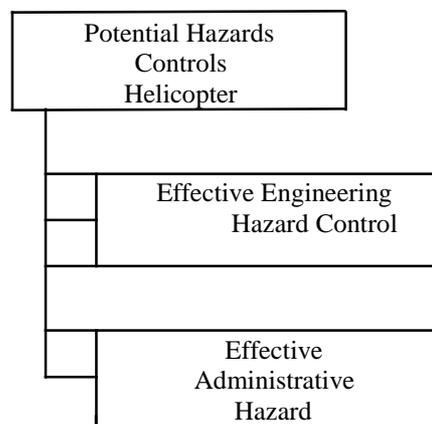


Fig. 2 - Effective hazard controls for helicopter operation

7. Conclusion

According to overall finding and results, health and safety practitioners and oil and gas drilling crew from Malaysian and Saudi Arabian oil and gas industries has been reported helicopter operation as moderately hazardous operation at offshore drilling sites with mean score 3.48 from Malaysian and 3.43 from Saudi Arabian offshore domain. Similarly, the participants from both targeted countries have point of agreement on environmental such as heavy wind and bad weather which can disturb the helicopter operation badly. Also, respondents indicated mechanical hazards such as derrick structural problem or damage as a big threat for property and workers lives. Furthermore, this study respondents also highlighted pilot error as major cause of accidents during helicopter operation at offshore oil and gas drilling sites. Lastly, the respondents of this study indicated that the engineering and administrative hazard controlling factors are effectual to minimize potential hazards during helicopter operation at targeted industries.

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