



# Evaluation of Workers Participation in Risk Assessment of Underwater Operations in the Oil and Gas Industry

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## Authors' contributions

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The offshore oil and gas industry performs risky operations leading to high incident rates requiring the need for risk assessment which is a critical component for maintaining safety. This study, therefore, was aimed at evaluating the participation of workers in carrying out risk assessment and whether the type of company they work for influences their participation in risk assessment. A cross-sectional design was utilized in carrying out this research in the Niger Delta. 401 employees of the Multinational and National oil and gas industries who carry out underwater operations responded to the Survey questionnaire. The data collected were analyzed for descriptive statistics, and cross-tabulation using XLSTAT Ver. 17 and SPSS Ver. 22. The result showed that significant relationship exists between participation in risk assessment and gender, years of work experience, and educational status at P-values  $\leq 0.005$ . In addition, the research showed that there is no significant difference between the participation in risk assessment among employees of

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Multinational and National oil and gas companies. It is recommended that organizations should ensure a mix of the workers groups studied when setting up Risk Assessment Teams to ensure a balanced risk assessment that when implemented will deliver on the intent of the activity.

**Keywords:** Risk assessment; risk analysis; hazards; risks; underwater; operations; oil and gas; industry; Niger Delta.

## 1. INTRODUCTION

Globally, underwater oil and gas operations and offshore operations are very risky, dangerous and accidents from these usually result in massive and devastating environmental and economic impacts. Underwater operations are carried out using a combination of several job tasks that include marine logistics for offshore mobilization, diving, pulling, lowering, lifting, dragging, cutting, welding among others [1,2]. Several authors have noted that these activities account for higher incident rates than other domains in the petroleum industry, ([3]; Amir-Heidari et al. 2016; [4,5]. According Asad et al. [6], work related fatality rate in the oil and gas drilling industry was 2.5 times higher than the construction industry between from years 2007 to 2012). Similarly, in their study, Bhardwaj, et al. [7] reported about 5301 combined safety events involving Falling load, Crane accidents, Spills, Fire, Anchor failure, Collusion, Explosion, Blowout, Capsizing, Structural damage, among others over 15-year period. A similar increase in offshore and marine incidents have been reported in Nigeria ([8]; Oyinkepreye and Robert, 2016). These high rates of fatalities, critical accidents and life threatening injuries have been attributed to several underlying factors such as operational, structural, composite, cross-cultural, poor natural conditions, design, equipment and human factors among others. ([9]; Asad et al. 2015; [10,11]).

As part of mitigating these risks, a comprehensive risk assessment is required as one of the critical tools in accidents prevention. To demonstrate the criticality of risk assessment, the Nigeria Mineral Oil Safety Regulations (MOSR), [12] requires a licensee or lessee to carry out a comprehensive risk analysis of the projects in accordance with API recommended practices and other internationally accepted procedures. This requires the formation of Risk Assessment Teams involving the participation of employees as laid out in ISO 45001: [13], Section 5.4. The Section requires an

organization to establish, implement and maintain a process (es) for workers participation at all applicable levels and “functions in the development, planning, implementation, performance evaluation and actions for improvement of the OH&S management system.”

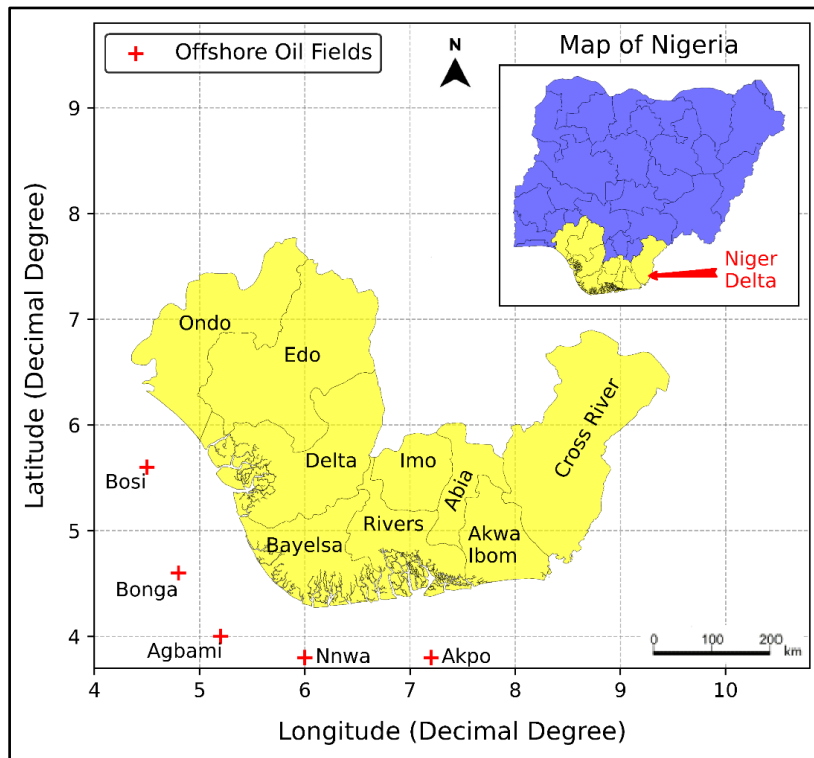
Shackleton et al. [14] noted that risk perception is highly subjective and influenced by individual's way of thinking and interpretation of the severity of a hazard because of experiences, beliefs, social norms among others. Brown, et al. [15] have also reported differences in risk perception between females and males. An optimum risk assessment team should therefore consider, and leverage on diversities like gender, educational status, work experience among others [16] in organization's risk assessment process [17].

Therefore, the objective of this research was to assess the workers participation in risk assessment by considering the relationships between marital status, gender, work experience and educational status.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

Niger Delta occupies the Gulf of Guinea continental margin in equatorial West Africa, between latitudes 4° and 6° N and longitudes 5° and 8°E [18] as shown in Map 1. The region shares boundary with Ogun, Osun, Ekiti, Kogi, Anambra, Enugu and Ebonyi states. The Niger Delta is host to Nigeria's huge deposits of oil and gas. This well-endowed ecosystem, which contains high concentrations of biodiversity on the planet, in addition to supporting the abundant flora and fauna, arable terrain that can sustain a wide variety of crops and economic trees, has more species of freshwater fish than any ecosystem in West Africa. Nigeria oil & gas reserves are situated in the region, contributing to 90% of government revenue with exploitation carried out by both Multinational and National oil and gas companies.



**Map 1. Study area**

Source: Map developed using ESRI ArcGIS 1: Map of study area showing some offshore oilfields

## 2.2 Research Design

Due to the need to obtain research findings that are representative and can be generalized, a cross-sectional research design was adopted. Cross-sectional study design is a type of observational study design where the investigator measures the cause and effect in a study population at the same time (Setia, 2016).

## 2.3 Sample and Sampling Technique

The total number of employees considered after factoring in the attrition rate was 7500 workers in the randomly selected National and Multinational oil and gas companies that are involved in offshore or underwater oil and gas related operations in the Niger Delta. This study adopted a purposive sampling technique, a type of non-probability sampling method where the sample is taken from a group of relevant people easy to contact or to reach.

Sample size was determined by using Equation (1) [19]

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

where, n is sample size, N is population size (7500) and  $e^2$  is degree of precision at 5% (0.05).

$$\text{Thus, } n = \frac{7500}{1+7500(0.05^2)} = 379.75 \approx 380$$

For this study, 418 copies of questionnaire were distributed after estimation of the attrition rate.

## 2.4 Hypothesis

The study hypothesis included the following;

- $H_{01}$  : There is no relationship between underwater workers participation in risk assessment and gender of workers.
- $H_{02}$  : There is no relationship between underwater workers participation in risk assessment and years of work experience.
- $H_{03}$  : There is no relationship between underwater workers participation in risk assessment and educational status.

## 2.5 Data Collection and Quality Control

The template and structure of the questionnaire were adopted from ISO 19900, ISO 19901-2, ISO 19904, ISO 19905-1 and industry Hazards Identification and Risk Assessment (HIRA) level 2. The ISO 19900 Standards referred to as ISO19900 series are a common basis addressing design requirements and assessments of all types of offshore structures

used by the petroleum and natural gas industries worldwide. They address “overall concept comprising models for describing actions, structural analyses, design rules, safety elements workmanship, quality management and national requirements, all of which are mutually dependent. The modification of any of these elements in isolation can cause an imbalance or inconsistency, with possible impact on the reliability inherent in the offshore structure. The implications involved in modifying one element, therefore, need to be considered in relation to all the elements and the overall reliability of the offshore structure.” The questionnaire had three (3) sections namely, sections A, B, and C. Section A contained information on socio-demographic data/occupational history. Section B contained items on the likelihood of underwater hazards, frequency or occurrence of hazards, and severity of hazards. Section C contained information on the consequences of the hazards. Questionnaire was offered to professionals and collated online using Google forms in line with COVID-19 protocols. Respondents were given assurance of confidentiality. Response Rate:  $(401 \div 418) \times 100 (\%) = 95.93\%$ . Out of 418 workers sampled 401 responded giving a response rate of 95.93%.

## 2.6 Data Analysis

Data from the questionnaire received from respondents were transcribed into Excel sheet and then transferred to XLSTAT version 17. Demographic analysis of the respondents was done using frequency analysis and percentage of proportion. Cross tabulation was used to understand the relationship Workers Participation in Risk Assessment of Underwater Operations in the Oil and Gas Industry. Thereafter, Chi-square test of independence was used in evaluating if the relationship observed in the cross-tabulation just exist in the sample dataset or if it exists in the population. Correspondence analysis was done to understand whether national or multinational company staff participated more in risk assessment. The frequency analysis and correspondence analysis were carried out using Microsoft XLSTAT version 17, while both the Cross-tabulation and Chi-square test of independence was done using SPSS version 26.

## 3. RESULTS

The result of the demographic analysis presented in Fig. 1 shows that more males participated in the study with 91.02 percent as against 8.98 percent female participation from

the total population of underwater operations personnel that participated in the study. The result presented in Fig. 1b showed that most of the participants were between the ages of 40-44 years and they constituted 37.66 percent of the total respondents while 25-29 year had the least participants with 0.25%. 95.5 percent of the participants as presented in Fig. 1c have tertiary education. The findings on the area of work experience reveal that 40.4 percent of the participants have more than 15 years' experience. Those with 1-5 years, 6-10 years and 11-15 years' experience made up 4.2 percent, 22.94 percent and 32.42 percent respectively (See Fig. 1d).

### 3.1 Cross-Tabulation of Underwater Workers Participation in Risk Assessment and Gender

#### Hypothesis 1:

$H_{01}$ : There is no relationship between underwater workers participation in risk assessment and gender of workers.

The cross-tabulation relating respondents' participation in risk assessment and gender is presented in Table 1. From the result, it was observed that male underwater workers have participated more in risk assessment than female workers. The Table shows that 351 out of 365 male respondents indicated that they have participated in risk assessment which accounted for 96.2 percent of male offshore workers that have participated in risk assessment while 14 out of 365 male respondents indicated that they have never participated in risk assessment which accounted for 3.8 percent of the male respondents that indicated that they have not participated in risk assessment. The result from Table 1 also showed that 86.1 percent of female offshore workers indicated that they have participated in risk assessment, while 13.9 percent indicated that they have never participated in risk assessment.

The chi-square test of independence was performed to assess the validity of the relationship between offshore workers participation in risk assessment and gender and the result is presented in Table 2. The result from Table 2 shows that there is significant relationship between underwater workers participation in risk assessment and gender,  $p = .007$ , which provides strong evidence that there is a relationship between underwater workers participation in risk assessment and gender.

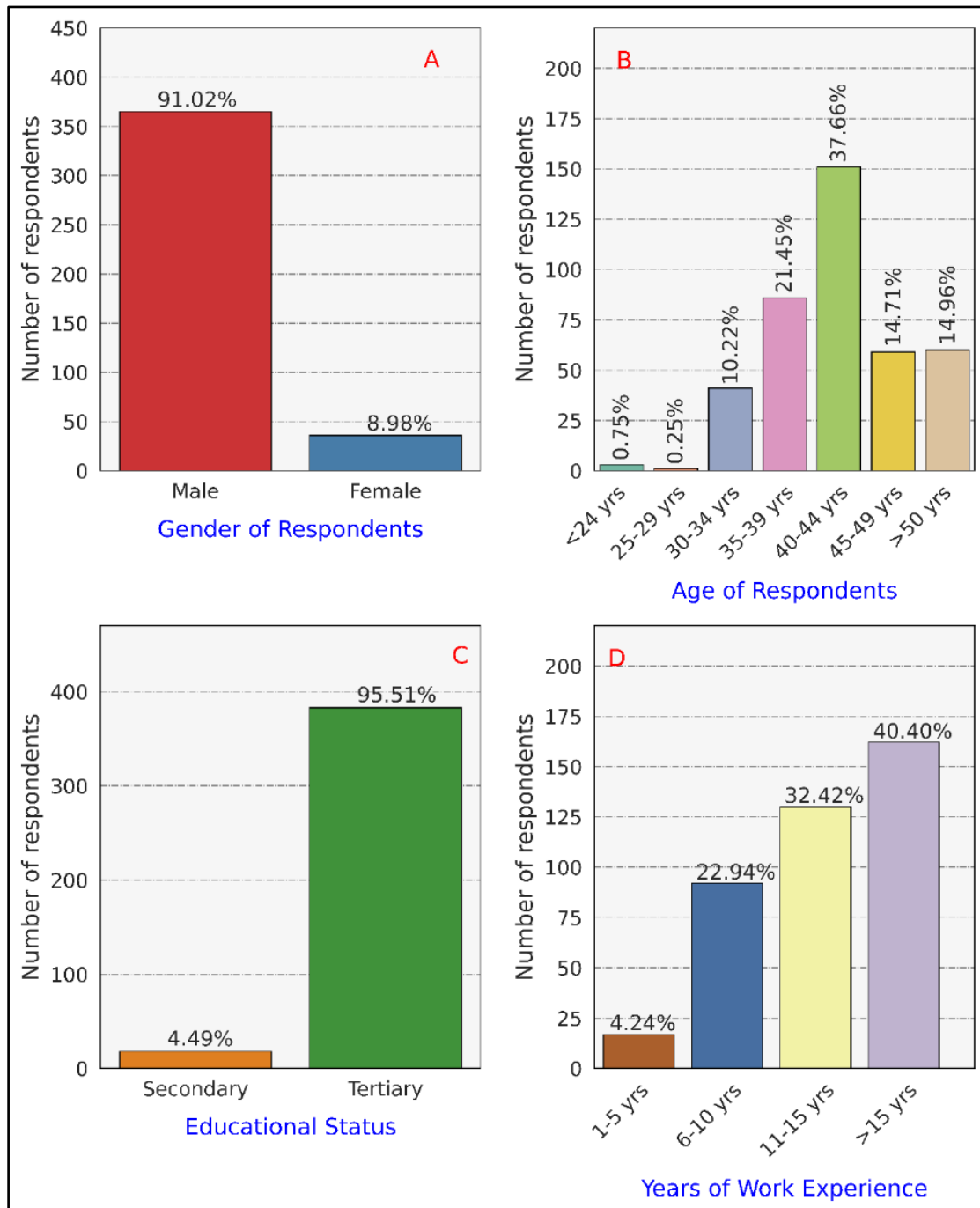


Fig. 1. Distribution of respondents according to demography

Table 1. Relationship between offshore workers participation in risk assessment and gender

Gender	I participated in a risk assessment*	I have never participated in a risk assessment*	Total
Male	351(96.2%)	14 (3.8%)	365 (100%)
Female	31(86.1%)	5 (3.9%)	36 (100%)
<b>Total</b>	<b>382 (95.3%)</b>	<b>19 (4.7%)</b>	<b>401(100%)</b>

\*Actual number and % Count within Gender

**Table 2. Relationship between underwater workers participation in risk assessment and gender of workers by Chi-square test**

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.337 <sup>a</sup>	1	.007		
Likelihood Ratio	5.196	1	.023		
Linear-by-Linear Association	7.319	1	.007		
N of Valid Cases	401				

a. 1 cell (25.0%) have expected count less than 5. The minimum expected count is 1.71.

### 3.2 Cross-Tabulation of Underwater Workers Participation in Risk Assessment and Years of Work Experience

#### Hypothesis 2:

H<sub>02</sub>: There is no relationship between underwater workers participation in risk assessment and years of work experience.

The cross-tabulation representing the relationship between underwater workers participation in risk assessment and years of working experience reveals that there was a linear relationship between the workers participation in risk assessment and years of work experience (See Table 3). It was observed that the more years of work experience workers had, the more they must have participated in risk assessment. 162 workers with more than 15 years of experience have participated in risk assessment followed by 124 (11-15 years), 82 (6-10 years) and 14 (1-5 years) respectively with each percentage participation as shown in Table 3.

The chi-square test of independence was performed to assess the validity of the relationship between underwater workers participation in risk assessment and years of work experience, and the result is presented in Table 4. The result shows that there is significant relationship between underwater workers participation in risk assessment and year of work experience,  $\chi^2 (3, N = 401) = 22.00, p = .000$ , providing strong evidence that there is a relationship between underwater workers participation in risk assessment and year of work experience.

### 3.3 Cross-Tabulation of Underwater Workers Participation in Risk Assessment and Educational Status

#### Hypothesis 3:

H<sub>03</sub>: There is no relationship between underwater workers participation in risk assessment and educational status.

The cross-tabulation showing the relationship between underwater workers participation in risk assessment and educational status is shown in Table 5. The result shows that more underwater workers with higher educational status have participated in risk assessment than workers with lower educational status. From Table 5, 96.3 percent of respondents with tertiary education indicated that they have participated in risk assessment, while 3.7 percent have never participated in risk assessment. Also, 72.2 percent of workers with secondary school education indicated that they have participated in risk assessment, while 27.8 percent indicated that they have never participated in risk assessment.

The chi-square test of independence was performed to assess the validity of the relationship between underwater workers participation in risk assessment and educational status with the result presented in Table 6. A significant relationship between workers participation in risk assessment and educational status  $\chi^2 (1, N = 401) = 22.16, p = .000$ , which provides strong evidence that there is a relationship between offshore workers participation in risk assessment and education status. It also indicated that education of underwater operators plays a major role in worker's willingness to participate in risk assessment.

### 3.4 Relationship between Worker Participation in Risk Assessment and Company Type

The result of the correspondence analysis revealing the relationship between workers participation in risk assessment and the type of company is presented in Fig. 2. The result reveals that multinational oil and gas workers participated more in risk assessment than

National/Local oil and gas workers. However, there was no significant difference in the participation of risk assessment between the Multinational and the National companies when the relationship was analyzed with Chi-square test of independence  $p = 0.686$ , (See Table 7). Nevertheless, the result showed that participation in risk assessment is considered serious in the oil and gas industry irrespective of location of the company.

**Table 3. Relationship between underwater workers participation in risk assessment and year of work**

Years of work experience	I participated in a risk assessment*	I have never participated in a risk assessment*	Total
1-5 years	14 (82.4%)	3(17.6)	17(100%)
6-10 years	82 (82.1%)	10 (10.9%)	92 (100%)
11-15 years	124 (95.4%)	6 (4.6%)	130 (100%)
> 15 years	162 (100%)	0 (0.0%)	162 (100%)
<b>Total</b>	<b>382 (95.3%)</b>	<b>19 (4.7%)</b>	<b>401 (100%)</b>

\*Actual number and % within Years of work experience

**Table 4. Relationship between offshore workers participation in risk assessment and years of work experience by Chi-square test**

	Value	Df	Asymptotic significance (2-sided)
Pearson Chi-Square	22.001 <sup>a</sup>	3	.000
Likelihood Ratio	25.240	3	.000
Linear-by-Linear Association	21.734	1	.000
N of Valid Cases	401		

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is .81.

**Table 5. Relationship between offshore workers participation in risk assessment and educational status**

Educational status	I participated in a risk assessment*	I have never participated in a risk*	Total
Secondary	13(72.2%)	5 (27.8%)	18 (100%)
Tertiary	369 (96.3%)	14 (3.7%)	383 (100%)
<b>Total</b>	<b>382 (95.3%)</b>	<b>19 (4.7%)</b>	<b>401(100%)</b>

\* Actual number and % within educational status

**Table 6. Relationship between offshore workers participation in risk assessment and educational status by Chi-square test**

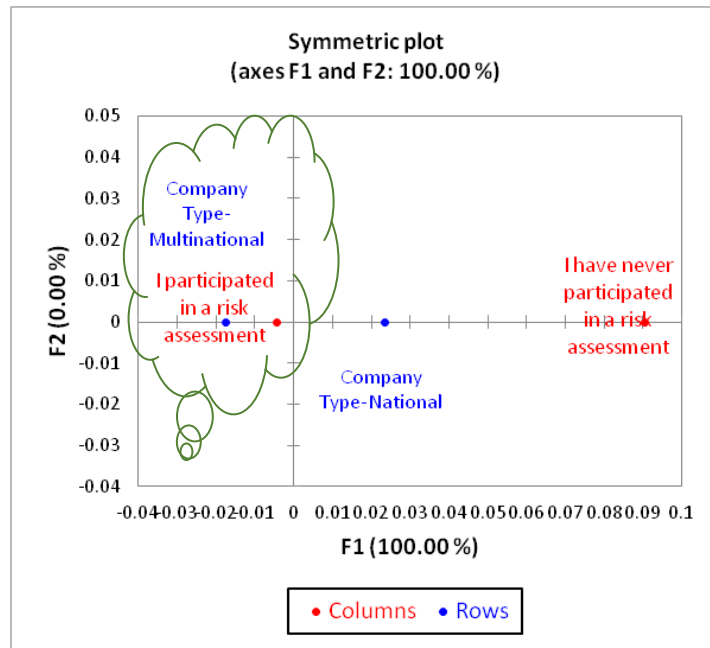
	Value	Df	Asymptotic significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	22.164 <sup>a</sup>	1	.000		
Likelihood Ratio	11.563	1	.001		
Linear-by-Linear Association	22.108	1	.000		
N of Valid Cases	401				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is .85.

b. Computed only for a 2x2 table

**Table 7. Chi-Square test of Independent for company participation in risk assessment**

<b>Chi-square (Observed value)</b>	0.163
<b>Chi-square (Critical value)</b>	3.841
<b>DF</b>	1
<b>p-value</b>	0.686
<b>Alpha</b>	0.05



**Fig. 2. Correspondence analysis of company participation in risk assessment**

#### 4. DISCUSSION

##### 4.1 Worker's Participation in Risk Assessment

The result showed that 95.3 percent of total respondents participated in risk assessment. The result provides an insight into the participation of personnel in risk assessment which shows a recognition of the need to manage hazards in underwater operations by preventing their release through early identification of the risks and provision of appropriate control measures. The workers participation is in line with Clause 5.4 of ISO45001:2018 which requires an organization to develop a process for workers to participate "in the development, planning, implementation, performance evaluation and actions for improvement of the OH&S management system." In order to realize the intended objective of developing an effective risk assessment, Team diversity is important as each member brings individual contributions based on their own competences and circumstances no matter how insignificant.

##### 4.2 Safety and Gender

The result also showed that majority of offshore workers are fully aware of the hazards present in underwater operations and the possible consequences likely to be faced should these hazards be released. The result from the study showed that there was a significant relationship between the offshore workers participation in risk assessment and gender,  $p = .007$ . This indicated that male offshore workers are more likely to participate in risk assessment than female offshore workers. This can be attributed to having more male workers in the oil and gas industry than females [20]. The significant result thus suggests that it is important that both genders participate in risk assessments as each gender has a unique contribution based on their different levels of unease. This suggestion thus agrees with the notion of the gender disparity in the perception of risk in the study on the impact of gender on risk perception and the implications for EU member states' national risk assessment processes by Brown, et al. [15]. They found that "females judged involuntary risks as being more



likely, having a greater impact, or being higher overall risk rating than their male counterparts.” Although this pattern did not apply when it came to rating the impact of fire. Logan and Walker [21] also acknowledged that women are more mindful of their personal safety and more likely to take precautions than men. Contrary to this, Oyeleke, et al. [22] reported that male respondents had significantly higher risk perception than their female counterparts from the study of the level of risk perception of the security personnel with respect to the different socio-demographic variables of gender, work experience, age marital status and educational qualification in Ibadan, Nigeria. Despite the differences in research findings about risk perception between females and males, it is safe to opine that the role of women and men in risk perception is important and must not be neglected when constituting a risk assessment Team.

### 4.3 Safety and Work Experience

The findings from the study showed that there was significant relationship between offshore workers participation in risk assessment and years of work experience. The result indicates that the more years of experience, the more workers are likely to have participated in risk assessment. The industry needs to leverage on the strength of the result and this group of the workforce to achieve integrity of the risk assessments to be carried out and applied. This assertion agrees with an earlier study by Bradford, [23], who maintained that the oil and gas industry is a highly hazardous workplace which could prove too difficult for an inexperienced worker because any minor error could result in multiples of catastrophic consequences. Thus, conducting Underwater operations risk assessment with a Team of inexperienced workforce may result in a disastrous outcome in terms of technical, health, safety and environmental among other inputs required for an effective risk assessment impact [24,25].

In addition, the more years of work with a strong participation in risk assessment gives the confidence that their conclusions as shown in this survey are correct, can be relied on and be used in setting the standards in the risk assessment. This study is also consistent with the findings of previous research [26] that work experience is correlated with better hazard identification and recognition because the

experience increases over time and workers gain more in-depth knowledge about their jobs and their performance improves. Penrose, [27] discussing the benefits of work experience noted that “experienced workers have increased self-understanding, maturity, independence and self-confidence.” Having this category of personnel involved in underwater operations risk assessment is undoubtedly beneficial in assuring the integrity of the outcome and controls. It is therefore important for more attention to be paid and training given to those with fewer years of experience to build their competences while ensuring full participation of experienced workers in carrying out underwater risk assessments as a means of preventing accidents among underwater operations workers.

Also, a significant relationship was observed between workers participation in risk assessment and educational status at  $p = .000$ , provides strong evidence that there is a relationship between offshore workers participation in risk assessment. More workers with tertiary education participated in the risk assessment indicating that education of underwater operators plays a major role in worker’s willingness to participate in risk assessment. The oil and gas industry relies mostly on the workforce with tertiary education qualification as this group of people can demonstrate better technical knowledge of the industry. This agrees with Maratha, et al. [16] who reported a statistically significant relationship between education, number of years worked among others, with the level of knowledge on occupational health hazards. The results therefore, provide an indication of the reliability of the outcome of risk assessments to be carried out involving this category of workers. They know exactly what risk assessment is and the impact of a poor risk assessment.

### 4.4 Comparative Analysis of National / Local and Multi-national Companies on Safety Participation

Another outcome of the research showed that while more workers of multinational companies participated in risk assessment compared to workers of national companies involved in underwater operational activities, the chi-square test of independence result showed that there was no significance difference in the participation in risk assessment between the multinational and national oil and gas company workers  $p = 0.686$ . This provides strong evidence that multinational

oil and gas company workers do not significantly participate in risk assessment more than the national oil and gas workers. From the result, participation in risk assessment is considered serious in the oil and gas industry irrespective of the location of the oil and gas company. This may be attributable to learning from incidents in the industry, reported losses due to accidents in the sector [28] and stringent regulations guiding the Nigerian oil and gas industry especially offshore operations. For example, the Mineral Oil Safety Regulations (MOSR), [12] requires a licensee or lessee to carry out a comprehensive risk analysis of the projects in accordance with API recommended practices and other internationally accepted procedures. The regulation also requires all operators (multinational or national) to be put in place a “scheme for risk analysis, system for implementation and follow up of result” while also laying out the requirement for Offshore Management System. As part of Worker Safety Reporting, MOSR [12] places the responsibility for ensuring sufficient safety and risk awareness training and certification of workers prior to deployment to offshore on the Manager. The goal is to prevent injuries. It is therefore, safe to say that regulations have been a useful tool in ensuring that both International and National Oil and Gas companies involved in underwater operations carryout risk assessments as part of operations [29,30]. The culture of participating in risk assessments in underwater oil and gas operations irrespective of the type of company is important in preventing accidents with their consequential outcomes across the sector [31,32].

## 5. CONCLUSION

The outcome of the research has shown that there was significant relationship between offshore workers participation in risk assessment and gender. There was also a significant relationship between offshore workers participation in risk assessment and years of work experience.

Furthermore, the study showed that there was significant relationship between offshore workers participation in risk assessment and educational status. Oil and Gas companies involved in underwater operations should leverage the peculiarities of each group in setting up underwater risk assessment teams as may be required. A good mix will provide an effective identification of hazards and mitigation measures

required in preventing incidents with their negative consequences on personnel, assets, environment, and company reputation.

There was no significant relationship between multinational oil and gas company workers involved in underwater operations participating in risk assessments and national company workers participating in risk assessment.

## CONSENT

As per international standard or university standard, Participants’ written consents have been collected and preserved by the author(s).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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