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Assessment of the Effectiveness of Medical Emergency Preparedness among Oil and Gas Platforms in the Niger Delta

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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 need for effective Medical Emergency Preparedness (MEP) systems in an offshore facility is of great importance due to the high Health Safety and Environment (HSE) risks to Personnel on Board in the terrain. Despite the great strides recorded in Nigeria's offshore oil and gas sector, little is known about the availability of a nationally constituted evaluation tool for offshore MEP systems in the oil and gas industry in Niger Delta. Hence, the call for a systematic national MEP framework based on the provisions of global best practices. This paper is aimed at assessing the effectiveness of the MEP framework of three selected offshore (jack up) oil and gas platforms in the Niger Delta. Data were obtained using a standard checklist and self-structured questionnaire and a purposive sampling technique adopted from a population of selected three jack up rigs operating in Niger Delta. The analysis was conducted using analysis of variance at 95% confidence interval. The effectiveness levels expressed as a function of numerical scores were used to carry out statistical comparative study to check for consistency in operability and quality. Results from the Welch robust test of equality of means showed to be significant ($p < 0.05$) for all 3 rigs. However, the pairwise post-analysis at 95% confidence interval showed that the mean difference between Rig1 and Rig2 were not significant (p-value = 0.352). But the other pairs (Rig1 versus Rig3 and Rig2

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versus Rig3) showed considerable differences in their mean scores with p-values of 0.001 and 0.001, respectively. It is concluded that the rig's functionality plays a role on the MEP system's effectiveness of jack up platforms in the Niger Delta. Therefore, the study advocates for a robust and holistic substantial national assessment tool for oil and gas regulatory authorities for evaluating and monitoring MEP systems of various offshore companies.

Keywords: Jack-up rig; medical emergency preparedness; oil and gas platform; Niger Delta.

1. INTRODUCTION

The offshore oil and gas work terrain is generally classified as a high risk to the Health, Safety and Environment (HSE) of workers due to its location and nature of operations. In terms of location, the interplay of its remoteness and the prevalent mete-ocean conditions are the major contributory factors behind this high risk as offshore workers do not have immediate access to secondary and tertiary medical health-care facilities especially in critical Medical Emergency (ME). Also, if the environmental conditions are not favourable for evacuation, this poses a survival challenge. For the nature of operations, the risks of injury and illness are due to exposure of on-board personnel to regiment work routines and operations [1].

The most encountered medical incidents in offshore jack up rigs fall within: (i.) Cardiovascular Incidents, (ii.) Traumatic injury emergencies, (iii.) Respiratory illnesses, (iv.) Musculoskeletal disorders, (v.) Infectious diseases, (vi.) Environment-induced illnesses, (vii.) Exposure to toxic substances (poisonings and anaphylaxis) and (viii.) Neurological-related emergencies [2, 3].

Typically, there is a medical care unit on-board but at an elementary level. A notable difference between this and a 'regular' health-care system onshore is in the workforce as that of the offshore is usually in small numbers, most times a single healthcare worker. Also, there may be no provision for advanced medical equipment. But the method used in providing care in a ME situation remains the same for both [1].

From the foregoing, it becomes an expectation in the offshore oil and gas industry that each operation site adopts a comprehensive Medical Emergency Response (MER) system in accordance with the industry's guidelines, regardless of whether the country of operation provides such legislations for the sector [4]. Though a well-structured Medical Emergency Preparedness (MEP) framework is vital in tracking, mitigating and managing HSE risks in the offshore work environment, however, having a MEP program in place is insufficient when not effectively implemented.

The research will explore the basic MEP requirements and guidelines for offshore oil and gas operations and evaluate the structure and cohesion of the MEP systems of most Jack-up platforms operational in the Niger Delta (ND) offshore province of Nigeria vis-à-vis international and local standards - World Health Organization (WHO), International Health Regulation (IHR), International Association of Drilling Contractors (IADC) and Federal Government of Nigeria Occupational Safety and Health (FGNOSH). This will create a pathway for MEP systems' optimization and effective implementation.

Nigeria's offshore oil and gas sector has made considerable strides in terms of its operation's safety, health, security and environmental management. Regulatory guidelines (as relevant to the nation's oil and gas industry) have been enacted and implemented by the Department of Petroleum Resources (DPR) and International Labour Organization (ILO) of Nigeria who maintain the responsibility of providing regulatory guidelines for operations across the entire oil and gas value chain in Nigeria; and sustainable Occupational Safety and Health (OSH) management guidelines respectively. Some of these include: (i.) International Labour Organization/Federal Ministry of Labour and Employment draft, 2020, (ii.) Nigeria Country Profile on Occupational Safety and Health 2016, (iii.) National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007, (iv.) The Factories Act, CAP F1, Laws of the Federation of Nigeria (LFN), 2004 and (v.) Petroleum (Drilling and Petroleum) Regulations, 1996 [5].

To the best of our knowledge, none of these presented substantial framework and parameters for assessing MEP of oil and gas operations in offshore has been used in Nigeria. This has made the evaluation of possible shortfalls and/or improvements in MEP to be an onerous task. Thus, the aim of this study was to evaluate and compare the effectiveness of the MEP framework of three selected offshore (jack up) oil and gas platforms in the Niger Delta. The objectives were to examine the current MEP programs and plans of different offshore (jack up) rigs in the Niger Delta region; and identify parameters (from local/international regulatory frameworks) for measuring the effectiveness of MEP systems in jack up oil and gas platforms within the Niger Delta offshore province.

2. METHODOLOGY

2.1 Study Area

This study was carried out in the Niger Delta (ND) region of Nigeria. ND is one of the world's leading petroleum provinces, which is situated at the tip of the Gulf of Guinea on the West Coast of Africa with coordinates of 5°19'20.40"N and 6°28'8.99"E. This region which extends across the south of Nigeria and parts of its Eastern region (about 29,900 square kilometres) is home to over 32 million people, occupying about 7.5% of Nigeria's land mass. The ND region consists of nine states (Abia, Akwa-Ibom, Bayelsa, Cross-River, Delta, Edo, Imo, Ondo, and Rivers) with over 800 producing wells and numerous petroleum product-related facilities [6].

National Petroleum Investment Management Services (NAPIMS) [7] publication shows that there are about 500 oil fields in ND with over 50% located onshore and the remaining located offshore (shallow and deep water). NAPIMS added that over 5200 wells have been drilled in the ND province. Oil and gas drilling operations in most offshore fields in the ND are commonly performed using Mobile Offshore Drilling Units (MODU) of which the jack up rig is one. However, drilling operations in the ND are not immune to HSE concerns as the varying factors leading to medical emergency in this region are not different from those obtainable in other offshore regions (North Sea, Gulf of Mexico, Persia Gulf) [8].

2.2 Study Population

The research population entails 3 jack-up rigs (out of a total of 7) within the ND geographical location, each comprising an average of 90 Personnel on Board (POB); out of which an average of 30 personnel per rig (Medics, HSE personnel and Top Management personnel) constituted the target population in the three selected offshore platforms, with each rig having its peculiar operation's purpose and functionality. The selected rigs were coded as Rig1 (Drilling jack up rig), Rig2 (Decommissioning, light weight, jack up rig), and Rig3 (Work-over jack up rig).

2.3 Sample Size

The sample size was calculated using Cochran's correlation for sample size as expressed in Etikan and Babatope [9].

$$n = \frac{N * X}{X + (N - 1)} \quad (1)$$

where n is the sample size, N is the study population, and X is the total score. X was calculated using Equation (2):

$$X = \frac{Z^2 * P\,(1 - P)}{M^2} \quad (2)$$

where P is the proportion of the population, M is the mean value, and Z is the critical value (1.96 at 95% confidence interval).

2.4 Inclusion Criteria

To be included in this study, respondents must have worked in the company for at least 5 years and must have worked in the rig for at least 2 years.

2.5 Data Collection Instrument

Primary data (in the form of questionnaire/Survey results) provided the foundation for the research analysis. Acquired secondary data (in the form of MER documents) from the target domain (all three offshore jack-up rigs) were utilized to substantiate the outcome of the primary data. This is in harmony with Reis [10] view on achieving a holistic research methodology. The primary data source (Questionnaire) consisted of 5 subsections viz: Section 1 (Questionnaire overview – Survey synopsis and confidentiality clause), Section 2 (Basic Respondent's Information and Basic MEP Effectiveness Indicator Questions), Section 3 (Medicals), Section 4 (Emergency Protocol), and Section 5 (Personnel / Management). A simple Yes/No response was used in Section 2 while a 5-point rating scale (1, 2, 3, 4 and 5) with response system of Very Low, Low, Medium, High, and Very High respectively were embedded within these closed-ended questions to capture the sample population's opinion of the various measuring parameters in Sections 3, 4 and 5.

2.6 Methods of Data Collection/ Instrumentation

The data collection process for the study followed a combination of quantitative and qualitative research methods. In terms of quantitative data collection, a primary quantitative research technique was utilized (through the use of a survey system). A notable feature of this data type is its uniqueness as data are collected directly from the target group rather than depending on already existing data [11]. Pre-research discussions were done with respondents via phone calls, WhatsApp application and Email to explain research and obtain informed consent. The existing company's MEP programs within a time space of ± 5 years were reviewed, and the assessment tool draft followed available local/international standards and guidelines for MER on offshore jack up platforms within the past 10 years.

2.6.1 Survey

According to Bhat [12], the use of survey research is one of the most basic tools in exploratory and evaluation-based research. Interestingly, these two characteristics underline the core of this research. Online survey (in the form of Questionnaire) was created and managed on the Google Form platform. Questionnaire content was mainly characterized by 30 spot-on questions (with each assessment parameter having 10 questions) within the context of the MEP evaluation parameters and sub-themes. As a necessity, the survey questions were preceded by the study synopsis and confidential-disclosure clause. These served as means of sensitizing the respondents on the purpose of the study and eliminate any liability-concerns (on the part of the respondents) for responses provided. In addition, it will also help to elicit unbiased responses [12]. The survey document was sent to the respective Managers, HSE Department of all three companies via e-mail in the form of an electronic link. These Managers disseminated it to the appropriate respondents, although responses were retrieved directly through the researcher's Google form landing page within a time frame of 21days. No questionnaire was voided because responses were in tandem with research, giving a response rate of about 100%.

2.6.2 Validity / reliability of instrument

To develop a MEP evaluation tool that is befitting for the target area (jack up oil and gas rigs) in the Niger Delta requires outlining measurable criteria on which the system will be scrutinized. It is crucial that the culled MEP evaluation parameters and sub-themes are outlined with common languages that match the subject (health) and agencies (offshore oil and gas jack up platforms) involved in the study. This will offer validity and reliability to the evaluation tool [13]. To achieve this, the evaluation instrument was sent to experts for validation, and it was based on the following International and local regulatory guidelines:

a. WHO, IHR (2005) Monitoring and Evaluation Framework.
b. IADC (2015) HSE Case Guidelines for Drilling Contractors, Issue 3.6
c. FGN (2020) National Policy on occupation safety and Health (revised)

From the foregoing, Table 1 was proposed as the key evaluation parameters and assessment sub-themes. A critical analysis was carried out on the proposed evaluation parameters by five experts (from a combination of two health-care facilities and three offshore companies within the study area) on MER systems development. However, from the expert judgment, the five parameters of Table 1 were narrowed down and presented under three essential parameters as:

a. Medicals
b. Emergency management protocol
c. Personnel/Management Aspects.

2.7 Method of Data Analysis

All data were managed statistically using IBM SPSS® 20 software. Cleaning/encoding of data was achieved using Microsoft Excel 2010. Given that the survey's response system was on a rating scale, responses generated were regarded as ordinal data, which for analysis purpose, needed to be transformed to quantitative data. According to Bevans [15], a variable represented in the ordinal form translates to a quantitative variable by taking the average value of all scores under the variable, given that the order of rating is numeric.

Table 1. Proposed MEP evaluation parameters/sub-themes [14]

Key assessment parameters	Sub-themes
Medicine	Pharmaceutical products, medical consumables, purchase, stockpiling, expiration.
Machine	Medical equipment, devices and technology, maintenance and abandonment policies.
Methodology	Health information and communication, Emergency awareness and responsiveness, ER command and control, risk assessment.
Man	Medical workforce, training and competency, qualification, health-care delivery, ER capacity and capability.
Management	Leadership and governance, health financing, continuity of MER system, logistics and operational support.

Following the weight-concept of the survey's response system grafted with the questionnaire (1, 2, 3, 4 and 5), each respondent's response under the measuring parameter was scored in terms of its corresponding weight. Hence, the total score for any given assessment parameter was obtained by the average value (in nearest whole number) of all scores under the ensuing questions. This gave the definition of the strength (effectiveness level) of the evaluation parameter. This distinctive approach was applied on a 'rig-basis for all survey data generated.

In this study, descriptive statistics was used to present the data and to check for the data normality (parametric and non-parametric testing). For data sets that showed to be normally distributed, the mean, median and mode were sufficient to demonstrate respondents' consensus levels (with regards to MEP effectiveness). However, quartile study becomes relevant for non-parametric data in terms of ascertaining the true magnitude of the effectiveness level of the measuring parameter in question. Furthermore, the normality test was used as a guide on the choice of inferential statistics to be utilized in comparing the level of MEP effectiveness within the three jack-up rigs [16]. The normality test was performed using Equations (3) and (4). The test of normality is rejected if any of these returns a result that is away from ± 2.

$$SE_S = \frac{S_K}{E_S} \tag{3}$$

$$SE_K = \frac{K_K}{E_K} \tag{4}$$

where SE_S is the standard error of skewness, SE_K is the standard error of kurtosis, S_K is the skewness, E_S is the standard error under skewness, K_K is the kurtosis, and E_K is the standard error under kurtosis.

One-factor Analysis of Variance (ANOVA) was carried out to ascertain the variability in the mean values and MEP effectiveness level of the measured parameters (medicals, ER protocol, personnel) amongst the three rig types. The two basic requirements (assumptions) that defined the suitability of the sample data/groups to a comparison of means statistical test (ANOVA) were (1) All statistical analysis was conducted assuming a confidence interval of 95% which represents a 0.05 significance level, and (2) The inferential statistical study conformed to the basic assumptions of a One-way ANOVA.

3. RESULTS AND DISCUSSION

3.1 Questionnaire Administration and Retrieval

Table 2 provides a summary of the total number of administered and retrieved copies of questionnaire with respect to the 3 rigs being studied. A total of 90 copies of questionnaire were distributed and 90 valid retrieved representing 100% retrieval rate.

Table 2. Questionnaire administration and retrieval

Jack up platform	Copies of questionnaire	
	Administered	Retrieved
Rig1	30	30
Rig2	30	30
Rig3	30	30

3.2 Average Rating Score of Respondent

The mean score of each respondent within the rating scale of 1 to 5 is presented in Table 3.

These values represent the input data (as used in SPSS) for the study analyses. All weighted means are either equal or greater than the criterion mean (3.00) except for four in Rig3, indicating that the respondents accepted all statements about the studied rigs except for four statements about Rig3.

Table 3. Average rating scores of respondents

Respondent	Rig types		
	Rig1	Rig2	Rig3
Respondent1	3.28	3.29	2.85
Respondent2	3.33	3.35	2.85
Respondent3	3.42	3.48	2.87
Respondent4	3.45	3.55	2.93
Respondent5	3.45	3.66	3.00
Respondent6	3.61	3.67	3.10
Respondent7	3.67	3.72	3.12
Respondent8	3.79	3.76	3.20
Respondent9	3.86	3.80	3.24
Respondent10	3.89	3.88	3.21
Respondent11	3.89	3.89	3.18
Respondent12	4.01	3.91	3.24
Respondent13	4.01	3.90	3.28
Respondent14	4.09	3.89	3.33
Respondent15	4.09	3.85	3.45
Respondent16	4.10	3.88	3.55
Respondent17	4.12	4.00	3.64
Respondent18	4.13	4.02	3.70
Respondent19	4.13	4.03	3.79
Respondent20	4.13	4.03	3.82
Respondent21	4.17	4.00	3.80
Respondent22	4.20	4.09	3.86
Respondent23	4.28	4.11	3.87
Respondent24	4.30	4.12	3.87
Respondent25	4.33	4.13	3.91
Respondent26	4.50	4.17	4.01
Respondent27	4.56	4.17	4.03
Respondent28	4.49	4.22	4.06
Respondent29	4.57	4.31	4.22
Respondent30	4.62	4.48	4.31

3.3 Descriptive Statistics of Data

Table 4 presents the descriptive statistics for the data across the three rigs. All weighted means were above the criterion mean for data from Rig1 and Rig2. On the contrary, some weighted means were below the criterion mean for data from Rig3. Accordingly, the overall weighted means are found to be in the order of Rig1>Rig2>Rig3. The general low standard errors for data set from all rigs indicate that the weighted means are closely clustered to the overall weighted mean. Although the range values indicate that the spread in data is in the order of Rig3>Rig1>Rig2. The interquartile range which is a representative indicator for studying variance is also in the same order of Rig3>Rig1>Rig2. The skewness values across the 3 rigs are within the benchmark for normality of data (± 1.96), clearly indicating that the data sets across the study rigs are normally distributed and validate the adoption of a parametric (statistical) test on the obtained data.

3.4 Effectiveness Level of MEP

The MEP effectiveness levels of the studied three rigs are presented in Fig. 1. The mean scores used compiled all responses across the three different key parameters for assessing MEP effectiveness levels, namely medicals, emergency protocol and personnel/management. The whisker-and-box plots for all 3 rigs seems to support a significant variation in the sample data of the rigs. A visual inspection of Fig. 1 shows that there is a high spread of data within the various rigs as the lower and upper whiskers for Rig1 and Rig3 are seen to be farther apart. The result of such spread in data is high range values as seen in Table 4. In the same manner, the interquartile range, a representative indicator for studying variance, for Rig1 and Rig3 are relatively high as seen by their longer rectangular boxes. The mean scores of Rig1 and Rig 2 are similar but higher than that of Rig3. This could be due to the design of the MEP framework on Rig1 and Rig2 which perform different functions but have similar hazards and health-related concerns. This is unlike what was obtainable in Rig3 which is a work-over platform with less hazards associated with its operations compared to Rig1 and Rig2. Also, drilling and decommissioning activities which go on in Rig1 and Rig2 usually take a longer time than maintenance (well work-over) operations associated with Rig3.

3.5 Test of Significant Difference in Effectiveness Level

The effectiveness level of the studied three rigs were compared for significant difference using a one-way ANOVA and the result is summarised in Table 5. The p-value (.000) obtained is less than the alpha value (0.05), indicating that there is a significant difference in the MEP effectiveness level in the studied three rigs.

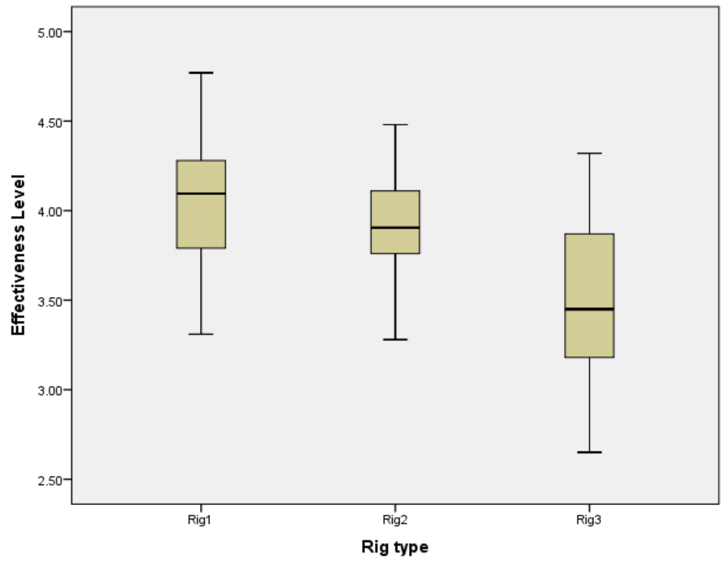

Fig. 1. Whisker-and-box plots for the 3 rigs

Table 4. Descriptive statistics result of data

Rig type	Description		Statistic	Std. Error
Rig1	Mean		4.0357	.07450
	95% CI for Mean	LB	3.8833	
		UB	4.1880	
	5% Trimmed Mean		4.0357	
	Median		4.0950	
	Variance		.167	
	Std. Deviation		.40805	
	Minimum		3.31	
	Maximum		4.77	
	Range		1.46	
	Interquartile Range		.53	
	Skewness		-.168	.427
	Kurtosis		-.551	.833
Rig2	Mean		3.9103	.05036
	95% CI for Mean	LB	3.8073	
		UB	4.0133	
	5% Trimmed Mean		3.9163	
	Median		3.9050	
	Variance		.076	
	Std. Deviation		.27585	
	Minimum		3.28	
	Maximum		4.48	
	Range		1.20	
	Interquartile Range		.36	
	Skewness		-.496	.427
	Kurtosis		.361	.833
Rig3	Mean		3.4930	.08537
	95% CI for Mean	LB	3.3184	
		UB	3.6676	
	5% Trimmed Mean		3.4943	
	Median		3.4500	
	Variance		.219	

Rig type	Description	Statistic	Std. Error
	Std. Deviation	.46761	
	Minimum	2.65	
	Maximum	4.32	
	Range	1.67	
	Interquartile Range	.70	
	Skewness	-.059	.427
	Kurtosis	-1.115	.833

CI – Confidence Interval; LB – Lower Bound; UB – Upper Bound

Table 5. One-way ANOVA test of significance in effectiveness level among rigs

	Effectiveness level				
	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	4.844	2	2.422	15.751	.000
Within Groups	13.376	87	.154		
Total	18.220	89			

4. CONCLUSION

This study assessed the effectiveness of existing medical emergency response systems on selected offshore oil and gas (jack up) platforms in the Nigeria's Niger Delta province using a systematic methodology adopted from international/local oil and gas regulatory frameworks (IADC, FGNOSH) and international health regulatory body's (WHO) framework for health emergency best practices. The medical emergency response effectiveness means scores for drilling and light-weight decommissioning jack up rigs compared considerably as against that for work-over jack up rig. Thus, the rig's functionality plays a role on the medical emergency response system's effectiveness of jack up platforms in the Niger Delta. Hence, it is recommended that a holistic and substantial national assessment tool should be developed by the local oil and gas regulatory authorities for evaluating and monitoring medical emergency response systems of various offshore companies.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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