DEVELOPING A FRAMEWORK FOR IMPLEMENTING HEALTH AND SAFETY MEASURES IN SMALL AND MEDIUM-SIZED OIL AND GAS CONSTRUCTION PROJECTS USING PARTIAL LEAST SQUARES STRUCTURAL EQUATION MODELING (PLS-SEM)

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Abstract
The oil and gas industry plays a pivotal role in Nigeria's economy, serving as a major driver of the nation's economic growth and development. It is one of the largest contributors to Nigeria's GNP, which emanates from the revenues generated through the exploration, production, and exportation of petroleum and natural gas. However, despite its economic importance, the industry still grapples with persistent issues regarding poor Health and Safety (H&S) performance. As a result, there has been increased need for adopting H&S measures that could help improve the situation. Therefore, this paper is aimed at developing a framework for implementation of health and safety measures for small and medium sized oil and gas construction projects in Nigeria with a view to improving the safety performance of the oil and gas companies using Partial Least Squares-Structural Equation Modelling (PLS-SEM). The findings revealed that, use of First aid kits with MIS of 4.28 is the most effective safety practice required on construction sites. It was also found that low level of compliance with occupational H&S regulations with MIS of 4.21 is the most severe challenge affecting the implementation of health and safety measures for SMEs oil and gas companies. Cost of workmen's compensation with the MIS of 3.79 is the most significant effect of implementation of health and safety measures on the cost of accidents. While H&S provision in condition of contract with MIS of 4.15 was ranked as the averagely implemented regulations for enhancing effectiveness of health and safety measures. This study concludes that use of first aid kits, use of Personal Protective Equipment (PPE), safety policy, safety personnel, health and safety risk assessment, health and safety training, good working environment, welfare facilities, and safety inductions are the effective safety measures required on construction sites by small and medium sized oil and gas construction projects.

Keywords: Model, Oil and Gas Construction Projects, PLS -SEM, Health and Safety Measures, SMEs.

Introduction

The health and safety (H&S) performance in the oil and gas industry remains a glaring challenge in its effort to tackle the developmental initiative of many nations including Nigeria, as a result, accidents not only result in considerable pain and suffering but also retard project productivity, quality, and time and consequently contribute to higher costs in the sector [7, 22]. However, cost implication of Health and safety prior to tendering and during execution are rarely considered during budget and often not discussed in site meetings by the relevant stakeholders for the Nigerian small and medium sized oil and gas companies. [1, 10]. Health and safety has been a significant concern for employees, employers, and governments worldwide for decades, prompting the Nigerian government to regulate the oil and gas industry in an effort to reduce occupational injuries and fatalities [11]. Soomro *et al.* [3] opined that Nigeria is among the countries having no adaptive Health and safety measures and regulations where small and medium sized oil and gas companies allocate little or no resources [17, 8] to H&S management. Benneth *et al.* [24] buttressed that, poor health and safety management in SMEs often results from a combination of interrelated factors, most of which revolve around the necessity for compliance with the legal framework. Bensonch *et al*. [1] revealed that, compliance with rules and regulations provides the foundation for workplace safety practices, its effectiveness relies considerably on how such measures are enforced by the relevant government authorities. The constrained capacity of SMEs to manage health and safety is usually related to a limited financial and human resources capacity, whereby most SMEs are characterized by tight budgets that limit their ability to invest in comprehensive safety measures or employ specialized personnel to oversee compliance [19, 21].

This economic limitation can lead to superficial or partial adherence to regulations, undermining the intended outcomes of workplace safety policies. In addition, the role of government bodies in effective enforcement is very important and poor monitoring and inconsistent enforcement, along with a lack of support mechanisms for SMEs, can lead to poor compliance [23]. For instance, insufficient inspection frequencies or leniency in penalizing violations may reduce the perceived importance of adhering to health and safety standards. Moreover, various barriers to accessible guidance or training programs provided by regulatory authorities may put SMEs in a position where they cannot gain the knowledge or competencies to implement safety protocols effectively. [16, 9]. Additionally, regulatory complexity may pose significant challenges, especially for small companies or those lacking a dedicated compliance team. These organizations often struggle to implement intricate legal requirements, which can lead to unintended non-compliance, particularly in sectors where health and safety risks are complex and require sector-specific solutions [1,7]. Hence, there is the role of cultural and organizational factors, which hold salience in the SME world such as, owners and managers of small enterprises might prefer short-term business needs to long-term investments in safety, considering regulatory compliance a bureaucratic burden rather than a strategic necessity [2, 18]. This mindset, combined with or circumscribing weak enforcement, tends to maintain a reactive instead of proactive approach to health and safety management.

The regulations of Health and Safety Environment (HSE) in Nigeria have received little attention, with little emphasis to strict adherence to health safety in the oil and gas industry and very minimal impact made by the inspection officers towards ensuring strict compliance [5]. The situation is quite tragic due to lack of existing functional legislation to that effect and there is no reliable data on accident cases in the oil and gas industry in Nigeria, because companies do not report accidents to appropriate ministry nor keep proper records on accidents. Occupational health and safety regulatory system in the country does not encourage mandatory reporting of accidents [15]. Recent data revealed that, within the petroleum industry of Nigeria, an estimated Oil 412 deaths had been recorded between 2018 and 2022 alone, due to negligence in the storage and distribution value chain. In a single year-from September 2021 to September 2022, the sector recorded 60 deaths and 62 injuries due to 34 incidents [6]. These statistics have shown the critical need for improvement in H&S measures within Nigeria's oil and gas industry and hence the need to address these challenges cannot be overemphasized if the nation is to protect the workforce and ensure the sustainable development of the sector. In the final analysis, the effectiveness of efforts towards health and safety management in the SMEs is largely prejudiced by implementation practices of government bodies, there being a need for compliance with the existing rules and regulations. Improvement in the mechanisms of enforcement, simplification of the compliance processes, and providing targeted support for the same is considered critical in fighting the manifold factors that lie underneath poor health and safety management in these enterprises [12, 9]. Hence, there is need to find a way of minimizing the rate of falls and injuries in Nigerian oil and gas industry. Osuoka and Asume [23] develop a framework for public participation in safety culture in the Nigeria extractive industries. Waqar *et al.* [37] conducted a similar study in Malaysia to develop a conceptual framework for safety measures in downstream oil and gas construction projects. A quantitative study, which consisted of a pilot survey and a main survey involving individuals who perform these types of researches, therefore employing exploratory factor analysis (EFA) for pilot survey data and structural equation modeling (SEM) for main survey data, safety factors recognised as critical included poor safety maintenance conducted to training of workers, insufficient safety procedures and inadequacies supervision. The results offer an understanding of the important safety factors in Malaysian oil and gas industry and can help in improving both theoretical and practical aspects of safety in the sector. This research helps to fill a gap in knowledge regarding construction safety in Malaysian oil and gas sector by highlighting the most important contributors to accidents in this industry. Numerous health and safety performance improvement models have been developed in recent years. For instance, Buerkle *et al*. [13] developed a model to measure the effectiveness of Health and safety management in the extractive construction sites. The model was based on 3P +1 namely policy, process, personnel and incentive factors. These core factors were measured by 590 attributes. The large number of attributes might not be practical in the context of SMEs because they did not show the interrelationship of the factors in reducing accidents on site The model was validated using large contractors in Thailand. It might be possible to test this model or a modified model within SMEs. This is because SMEs and large organisations are different in terms of their characteristics. Large organisations are more properly resourced and organized than SMEs. Summarily, there exist limited studies on a model for effective implementation of health and safety measures for small and medium sized oil and gas companies in Nigeria as the existing ones are too generic and are particular to foreign and multi–national construction firms which are characterized with shortcomings of not capturing the peculiarities of Nigeria. Itaman *et al*. [20], Pilbeam and Colin [12] revealed that, safety practices lack necessary framework for the implementation of health and safety measures in the oil and gas industry with particular emphasis to the small and medium sized companies and thus leading to increase in accidents on construction sites and cost of compensation to injured workers. This brings about ineffective cost performance of projects. It is against this backdrop that this research focuses on the development of model for implementation of health and safety measures for Small and Medium Sized oil and gas companies in Nigeria.

Conceptual model for the implementation of health and safety measures for Small and Medium Sized oil and gas companies

According to Crovini *et al.* [9], concept is a plan, vision, or a symbolic representation of an abstract idea, while conceptual model in research shows the researchers' position on the research problem, which gives direction to the study, and further shows the relationships that exist between different constructs that the study intends to investigate. It may be an adoption of a model used in a previous study with modifications to suit the present investigation. Thus, it is referred to as, an organisation, or matrix of concepts that provide a focus for enquiry. The conceptual model, therefore, gives direction and rationale for undertaking the subsequent stage (methodology) of this research process [14]. This section focuses on the development of a model based on the literature review of H&S measures implementation. From the review it was identified that implementation of health and safety measures may lead to accident prevention which have economic impact on contractors, it is necessary to have a conceptual model that brings together these key parameters to be investigated to aid the data collection phase of the study.

In the literature review, it was argued that implementation of safety measures could offer decision support tools for health and safety management in the construction industry thereby widening safety measures implementation efforts. This section consolidates that argument by putting forward a model that establishes the benefits of accident prevention and integrates these elements to highlight the potential economic case for accident prevention. A logical progression of this argument is that the greater the investment in health and safety measures, the greater the reduction in accident and improvement in performance through first aid, PPE, safety training, safety promotion and safety personnel, during project delivery this translates into greater accident costs. A significant challenge for contractors is to reduce accidents by taking effective action or measures to reduce the risks of accidents and ill health [12, 37]. The extractive site safety implementation model to be developed in this research would depend on the understanding of good safety measures which can be achieved through management commitment, and it is the first safety best practice identified, and one which will be essential to any good safety program.

The second part is about the implementation of safety policy, H&S Regulations, safety rules, safety organization chart, assigning of safety responsibilities to personnel on site, compliance of safety rules with legislation, safe working environment, safety induction and performance monitoring for subcontractors on site and selection of subcontractors based on safety policy. The third part consists of safety training of contractor's workers on site. The training includes induction training of persons at site, providing updated safety information to all the workers on site and to promote safety on construction site by displaying proper sign boards and by introducing different award schemes on site. At this level the H&S critical positions must have been identified in other to build a background to customize the firm's policy. The next stage is to identify the challenges to effective implementation of H&S measures and its effect on the safety performance. Emergency response procedures, which are plans for handling emergencies that may occur on the construction site, including, but not limited to, injuries resulting from falls, fires, explosions and releases of hazardous materials including investigation including accident recording and analysis should be an integral part of the safety strategies for enhancing safety performance which should be on continuous basis. The last part is about the safety review to evaluate safety features of completed projects and to identify any site conditions that may negatively affect safety in an effort to implement the necessary changes to improve safety of the ongoing project and for the future projects of the company. Safety review may include safety hazard review, site safety policy review and the safety audit for the construction site.

Method of Data Analysis

The target population for this study constitutes the number of registered construction firms of small and medium sized medium size categories (ISO certified) with Corporate Affairs Commission (CAC), Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) for midstream and downstream operations. The respondents include the owners or managers, professional members and non-professionals, HSE personnel who are staff of the oil and gas industry. A list of 3,000 oil and gas SMEs companies was obtained from the most recent directory of the Corporate Affairs Commission of Nigeria after series of visit. The research design used for the study was descriptive sample survey, whereby the questionnaire been the main instrument for the study was administered to the contractors and consultants of the companies and the results were analyzed using Partial Least Squares-Structural Equation Modeling (PLS-SEM).

The survey strategy uses a "closed ended" type of questionnaire for this study. Questionnaire were self-administered to the respondents, by the researcher. The questionnaire was divided into sections. Section a required information on respondent's background. While the other sections were for more specific questions which raises response on the implementation of health and safety measures required in the oil and gas activities, challenges affecting the implementation of safety measures by oil and gas SMEs and the strategies for improving the level of implementation of safety measures by oil and gas SMEs. The respondents were asked to rank the various sections using a 5-point scale. The frequency of occurrence included: 1= least effect, 2=Low effect, 3= Moderately low effect, 4= High effect and 5= Very high effect (for likelihood of effect of safety measure on rate of accidents occurrence) and 1= Not implemented, 2= Partially implemented, 3= Fairly implemented, 4= Averagely implemented and 5= Completely implemented. Effective safety measures required on oil and gas site occurrence and a multiple response for the other sections. In order to analyze the data got, the researcher used the Partial Least Square Structural Equation Modeling (PLS-SEM).

Structural Equation Model

Structural Equation Model (SEM) is a statistical model that seeks to explain the relationships among multiple variables. The two types include: Variance-based PLS (VBPLS) and Covariance-based PLS (CBPLS). VBPLS
Advantage over CBPLS is that:

I. It has the ability to accommodate constructs measured by a large number of variables;
II. It allows for greater complexity within the model and can be used with non-parametric data;
III. Sample size requirements are not as robust and dependent on power analysis for a determination of an appropriate sample size;
IV. It attempts to maximize variance explained in the latent variables through the relationship with the independent variables.

Structural Equation Model (SEM) is a method for estimating, representing and testing a theoretical network of mostly linear relations between observed and construct variables. It is more comprehensive and adjustable than any other path (such as multiple regression, correlation and ANOVA), providing means of governing not only for extraneous variables, but also for measurement errors as well [36].

SEM is said to be a second-generation multivariate data analysis (MDA) incorporating certain aspects of factor analysis and regression analysis in a bid to evaluate the relationship between defined measurement variables and predetermined constructs [29]. Recent use of this method in the development and testing of hypotheses has become common in most social science research [26]. As stated by Alzahrani *et al.* [35], in most researches, the key reason for using this method is its ability to test simultaneously series of interrelated dependency relationships that occur in various sets of constructs, calculated by multiple variables and at the same time account for measurement error.

For questionnaire-based research, each indicator represents a particular question. Latent variables (or construct, concept, factor). Latent variables are normally drawn as circles. Latent variables are used to represent phenomena that cannot be measured directly [30]. Path relationships (correlational, one-way paths, or two-way paths). These relationships are defined using arrows. Davies *et al* [27] revealed that, in structural equation modeling (SEM), exogenous constructs are latent variables that act as independent variables in the model. They are considered the starting points or sources of influence in the model due to the fact that, it does not possess any other variables gearing to it, which means does not possess any predecessors. This depicts that, exogenous constructs are not influenced by other variables within the model; instead, they influence or cause changes in other variables. In such a way, these constructs are the initial factors that drive the relationships in the model, and it represent causes rather than effects. For example, in a model exploring the impact of work environment on job satisfaction, the work environment might be an exogenous construct, influencing other variables like job motivation or job satisfaction, but it itself is not influenced by any other constructs in the model.

SEM is said to be a second-generation Multivariate Data Analysis (MDA) incorporating certain aspects of factor analysis and regression analysis in a bid to evaluate the relationship between defined measurement variables and predetermined constructs [8, 31]. Recent use of this method in the development and testing of hypotheses has become common in most social science research. As stated by Paraschi *et al.* [32], in most researches, the key reason for using this method is its ability to test simultaneously series of interrelated dependency relationships that occur in various sets of constructs, calculated by multiple variables and at the same time account for measurement error.

According to Trail *et al*. [38] there are three types of SEM (CB-SEM, PLS-SEM and GSCA) with the two most common being CB-SEM and PLS-SEM. This research used PLS-SEM, specifically Smart PLS Version 3.3.2 and SPSS V 23 S to determine the hypothesized relationship between the constructs. Study of Wang *et al.* [42] buttressed that, PLS-SEM is the most popular SEM technique in various fields that has gained considerable attention. Its use is mainly evident in numerous fields, including; business marketing, e-business, organizational management, international management, and human resource management, where it helps to analyze complex relationships, optimize decision-making, and enhance overall performance through data-driven insights. In extractive-related studies, PLS-SEM has equally gained significant recognition. According to Ciavolino *et al.* [43], besides the benefit of PLS-SEM is it has higher statistical power which is best to use in the exploratory study. Initially, a preliminary analysis was carried out to confirm the fitness of data for PLS-SEM modelling. Secondly, PLS-SEM validity of measurement and structural model along with hypotheses test were carried out. In such case, the measurement model fixes the relationship between constructs and attributes while the structural model determines the relationship between constructs and unobserved variables. Lastly, the evaluation matrix was carried out to identify the real condition of all categories of construction in terms of safety performance

Assessment of PLS-SEM

PLS-SEM is assessed using the coefficient of determination (R2) of each of the latent constructs. Coefficient of determination (R2) is used to describe the overall goodness of fit of an estimated model of one or more independent variables. A value of zero means perfect fit, while a value < 0.08 is considered good fit [41]. However, some authors accept values ≤ 0.10 [39].

Coefficient of determination (R^2)

Coefficient of determination (R^2) measures the relationship of a constructs explained variance to its total variance, at this stage each dependent construct is assessed. It is suggested that R^2 for endogenous constructs should be greater than 0.1 [43]. However, interpreting R^2 value is based on research discipline, in general the R^2 values considered are 0.75, 0.50 or 0.25 and endogenous constructs can be described as substantial prediction, moderate prediction and weak prediction, respectively [29, 41]. On the other hand, Trail *et al*. [38] establish that, in social sciences, R^2 values from 0.04 to 0.16 can be described as moderately weak and from 0.25 to 0.49 are considered moderately strong. Considering this criteria, PLS-SEM algorithm gave weak values for H&S measures 0.077 (7.7%) and strategies for improving implementation of safety measures 0.160 (16%). While a moderately strong value was gotten for cost of accident 0.282 (28.2%) and improved safety performance 0.834 (83.4%). In addition, they all complied with Liengaard and Dybro [41] rule by being above 0.1. However, the improved safety performance construct was considered the strongest, explaining 83.3% of the variance. Figure 1 shows the structural model with path coefficients and R^2 and structural model with t-values respectively with respect to the discussions.

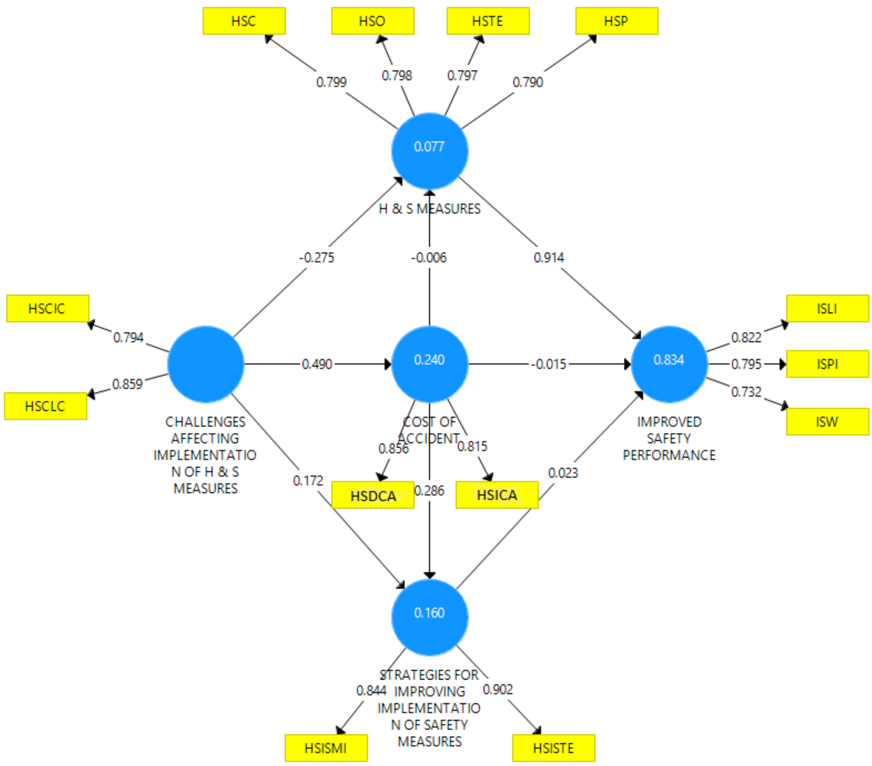

Figure 1: Structural Model with Path Coefficients and R^2

Discussion of findings from the Model Result

PLS-SEM was used to test both the direct and indirect relationships among all the constructs. The predictive power was analysed using R^2 as shown in figure 5.42. A moderately strong predictive value was gotten for cost of accident 0.282 (28.2%) and safety performance 0.834 (83.4%). In addition, all researchers complied with Capeda *et al.* [40] rule by being above 0.1. However, safety performance construct was considered the strongest, explaining 83.3% of the variance. Furthermore, the structural model path coefficients determined from the t-value, and significance level (p-value) for all hypothesized relationships in the model indicates that maximum six (6) of the paths (H1, H2, H3, H4, H8 and H9) were strongly significant and only three (3) paths (H5, H6 and H7) did not meet the required value of the rule of thumb.

Considering the effect size of the model, it was deduced that H&S Measures to safety performance (H8) had a large effect size with f^2 value of 4.889. Challenges affecting implementation of safety measures to cost of accident (H2) had f^2 value of 0.316 was said to have medium effect on the model. While challenges affecting implementation of safety measures to strategies for improving implementation of safety measures (H1) had f^2 value of 0.027, challenges affecting implementation of safety measures to H&S Measures (H3) had a F2 value of 0.062 and cost of accidents to strategies (H4) had a f^2 of 0.074 which were said to be having small effect on the model. In addition, cost of accident to H&S measures(H5) had f^2 value of 0.000, strategies to safety performance (H6) had f2 value of 0.003 and cost of accident to safety performance (H7) had a f2 value of 0.001 were indicated to have no effect on the model.

Looking at the predictive relevance of the constructs in the model it was indicated that, strategies for improving implementation of safety measures and H & S measures had Q^2value 0.111 and 0.047 respectively had a small predictive relevance. Cost of accident with Q2value was found to have medium predictive relevance on the model, while safety performance with Q^2value of 0.504 had a large predictive relevance in the model fitness, therefore, the model can be said to have a good predictive value.

The SRMR value of 0.10 was obtained and this was considered accepted meaning that the model has a good fitness.

Conclusion

Upon conducting an extensive review and analysis, this study arrives at the following conclusions: This study concludes that use of first aid kits, use of Personal Protective Equipment (PPE), safety policy, safety personnel, health and safety risk assessment, health and safety training, good working environment, welfare facilities, and safety inductions are the effective safety measures required on construction sites by small and medium sized construction firms. This study also concludes that the challenges affecting the implementation of safety measures by Small and Medium Sized oil and gas companies are low level of compliance with occupational health and safety regulations, management commitment, lack of adequate information on occupational health and safety (OHS), weak national occupational health and safety (OHS) standards, and weak legal structures. On the effect of implementation of safety measures on the cost of accidents, this study concludes that; disruption of site activities, personal injury claims, cost of workmen's compensation, time lost due to absence from work, loss of confidence and reputation, reduction in productivity, and strained management-labour relationship are the effect of implementation of safety measures on cost of accidents. This study also concludes that provision of personal protective equipment, communication of H&S policy and programs to staff, use of building codes of practice, collective protective equipment such as scaffolding, safety nets fencing and accessibility, provide first aid supplies, deal with any hazards promptly, training and enforcement, risk awareness, management and tolerance, and safety inspection are the effective strategies used for improving the level of implementation of health and safety measures in the oil and gas industry by Small and Medium Sized oil and gas companies.

The conceptual model was validated through findings derived from PLS-SEM conducted using Smart PLS 3.3.2. The analysis of the SEM revealed that there was no positive statistically significant relationship between Cost of accident and H&S measures, Strategies for improving implementation of safety measures and Improved safety performance, Cost of accident and Improved safety performance. The SEM analysis also revealed that positive statistical significant relationship exists between Challenges affecting implementation of H&S measures and Strategies for improving implementation of safety measures, Challenges affecting implementation of H&S measures and Cost of accident, challenges affecting implementation of H&S Measures and H&S measures, Cost of accident and Strategies for improving implementation of safety measures, H&S Measures and Improved safety performance and finally, the analysis also revealed that the indirect relationship between challenges affecting implementation of H&S measures and Improved safety performance was also significant. As a result of these, the study concluded that the constructs that constitute the strategies for improving the implementation of health and safety measures are: training and enforcement, awareness and advocacy, safety programs and monitoring and inspection, and all these constructs showed positive significant effects on improved safety performance. The research therefore concluded that the SMEs in Nigeria can adopt the developed model to ensure effective implementation of health and safety measures to enhance safety performance in the oil and gas industry.

Recommendations

To ensure effective implementation of health and safety measures for SMEs in the Nigerian oil and gas industry, the following recommendations are drawn from the conclusions of the study:

I. SMEs should encourage and enhance the implementation of first aid kits, Personal Protective Equipment (PPE) and safety policy as they have been identified as the effective health and safety measures required in oil and gas activities to further reduce accidents and unnecessary expenses that may amount as result of accident.
II. Since it has been identified that; low level of compliance with occupational health and safety regulations, management commitment, lack of adequate information on occupational health and safety (OHS), weak national occupational health and safety (OHS) standards, and weak legal structures are the major challenges affecting the implementation of health and safety

measures by SMEs. This study recommends that companies should have a more stringent in-house rules by incorporating the 'carrot and stick' approach (that is, a combination of reward and punishment) to induce good behaviour. In addition, reduction in cost of safety training, adoption of seminars and workshops to engage SMEs to be part of OHS activities, and ensuring the right safety culture for professionals and site workers is crucial for the advancement of OHS and for the wellbeing of the workers.

III. Disruption of site activities, personal injury claims, cost of workmen's compensation, time lost due to absence from work, loss of confidence and reputation, reduction in productivity, and strained management-labour relationship have been identified to be the effect of implementation of safety measures on the cost of accidents, therefore, this study recommends that, though construction professionals think profit will decrease and safety cost will increase when safety measures are implemented on construction projects. However, investment in health and safety measures will increase profitability by increasing productivity and uplifting employee confidence.

IV. This research recommend that companies should ensure provision of adequate personal protective equipment, communication of H&S policy and programs to staff, encourage the use of building codes of practice, provide collective protective equipment such as scaffolding, safety nets fencing and accessibility, provide first aid supplies, deal with any hazards promptly, training and enforcement risk awareness, management and tolerance, and conduct safety inspections at predetermined intervals so as to improve the level of implementation of health and safety measure on SMEs companies.

V. Organizations and oil and gas stakeholders should encourage, ensure, and promote the proper implementation and adoption of the developed and validated model for health and safety measure implementation as it is intended to support SMEs companies as well as professionals in identifying safety issues, putting measures in place to curb challenges inhibiting safety measures implementation and improving on the safety practices in the SMEs companies in order to enhance efficient productivity, competitive advantage and boost performance.

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