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Development of Model for Implementation of Safety Measures for Small and Medium Sized Construction Firms in Abuja, Nigeria using Partial Least Square-Structural Equation Modelling

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Abstract

The construction industry is a very important sector of the Nigerian economy. It contributes significantly to the Gross National Product. Poor H&S performance remains at high levels as evidenced by a high number of injuries and work related illnesses. As a result, there has been increased need for adopting H&S safety measures that could help improve the situation. Therefore, this paper is aimed at developing a model for implementation of safety measures for small and medium sized construction firms (construction SMEs) in Abuja with a view to improving the safety performance of construction firms 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 safety measures by construction SMEs. Cost of workmen's compensation with the MIS of 3.79 is the most significant effect of implementation of 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 safety measures. The findings reveal that the PLS-SEM is a model that evaluates a data as a collective entity.

Keywords: *Implementation, Model, PLS -SEM, Safety measures, SMEs.*

Introduction

Aim and Objectives

The aim of this research is to develop a model for implementing safety measures for small and medium sized construction firms in Abuja, Nigeria with a view to improving safety performance of construction SMEs. In order to achieve the aim of the study, the following objectives were formulated to:

i. To identify and examine the effective safety measures required on construction SMEs.
ii. To examine the challenges affecting the implementation of safety measures on construction sites by small and medium sized construction firms in Abuja, Nigeria.
iii. To determine the effect of implementation of safety measures on the cost of accidents by small and medium sized construction firms.
iv. To examine the strategies for improving the level of implementation of safety measures for small and medium sized construction firms.
v. To develop and validate a model for implementation of safety measures on construction SMEs by small and medium sized construction firms in Abuja, Nigeria

Statement of Problem

The H&S performance of the industry remains a glaring challenge in its effort to tackle the developmental initiative of many nations including Nigeria (Okoye and Okolie, 2014). Accidents not only result in considerable pain and suffering but also retard project productivity, quality, and time and consequently add to the cost of construction (Okoye and Okolie, 2014). However, cost implication of H&S prior to tendering and during construction are rarely considered during budget and often not discussed in site meetings by the relevant stakeholders for the Nigerian small and medium sized construction firms. Diugwu *et al.* (2013). H&S has therefore been a major source of concern for employees, employers and government for the past decades globally, and effort to reduce the number of occupational injuries and fatalities by the Nigerian government opted to regulate the construction industry (Olutuase *et al.*, 2014).

Diugwu *et al.* (2013) opined that Nigeria is among the countries having no adaptive H&S measures and regulations where small and medium sized construction firms allocate little or no resources to H&S management. Okoye and Okolie (2014) further suggested that effective management of H&S is motivated by various factors which could be centred on the need to abide by existing rules and regulations. In the same vein, Bima *et al*. (2015) revealed that legislation on H&S are endorsed by the Nigerian government, including International Labour Organisation (ILO) conventions. However, their implementation by the relevant government bodies and workers is poor (Shittu *et al*., 2015a and b; Shittu *et al*., 2016; David *et al*., 2018).

The regulations of OSH in Nigeria has received little attention, with little emphasis to strict adherence to safety in the construction industry and very minimal impact made by the inspection officers towards ensuring strict compliance. The situation is quite tragic due to lack of existing functional legislation to that effect. There is no reliable data on accident cases on construction sites in Nigeria, because contractors do not report accidents at appropriate ministry nor keep proper records on accidents. Occupational health and safety regulatory system in the country does not encourage mandatory reporting of accidents (Idoro 2008). A study by Ezenwa (2001) over a 10-year period (1987-1996) of fatal injuries reported to the Inspectorate Division of Federal Ministry of Labour and Productivity indicated that Nigeria's construction industry is responsible for about 7.5% of all occupational accidents, 49.5% of these injuries were fatal, 12.2% of partial disabilities and 7.4% of minor injuries (Umeokafor, Isaac, Jones & Umeadi, 2014). The construction industry has been ranked the second highest in terms of injuries, after mine. In fact between 1990 and 1994, the overall fatality rate as recorded is 22% of the above reported cases. This explains why Idoro (2011) in a study of 42 construction contractors in Nigeria, found that in 2006 the best safety record is 5 injuries per worker and 2 accidents per 100 workers.

Hence, there is need to find a way of minimizing the rate of falls and injuries in Nigerian construction industry. Machfudiyanto *et al.* (2017) develop a framework of construction safety culture in Indonesia. Zid *et al.* (2018) conducted a similar study in Malaysia to develop a conceptual framework for safety measures in construction industry. Many other H&S performance improvement models have been developed in recent years. For example, Teo and Ling (2006) developed a model to measure the effectiveness of H&S management of 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 safety measures by small and medium sized construction firms 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.

Awwad *et al*. (2016) added that safety practices lack necessary framework for the implementation of safety measures on construction projects with particular emphasis to the small and medium sized construction firms 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 safety measures for the small and medium sized construction firms in Nigeria

Conceptual model for the Implementation of Safety Measures for Small and Medium Sized Construction Firms

A concept is a plan, vision, or a symbolic representation of an abstract idea**.** A conceptual model in research shows the researcher's 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 (Saidu, 2016).

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 (Kecklund *et al*., 2016).

The construction 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 customise 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 as indicated in Figure 1.

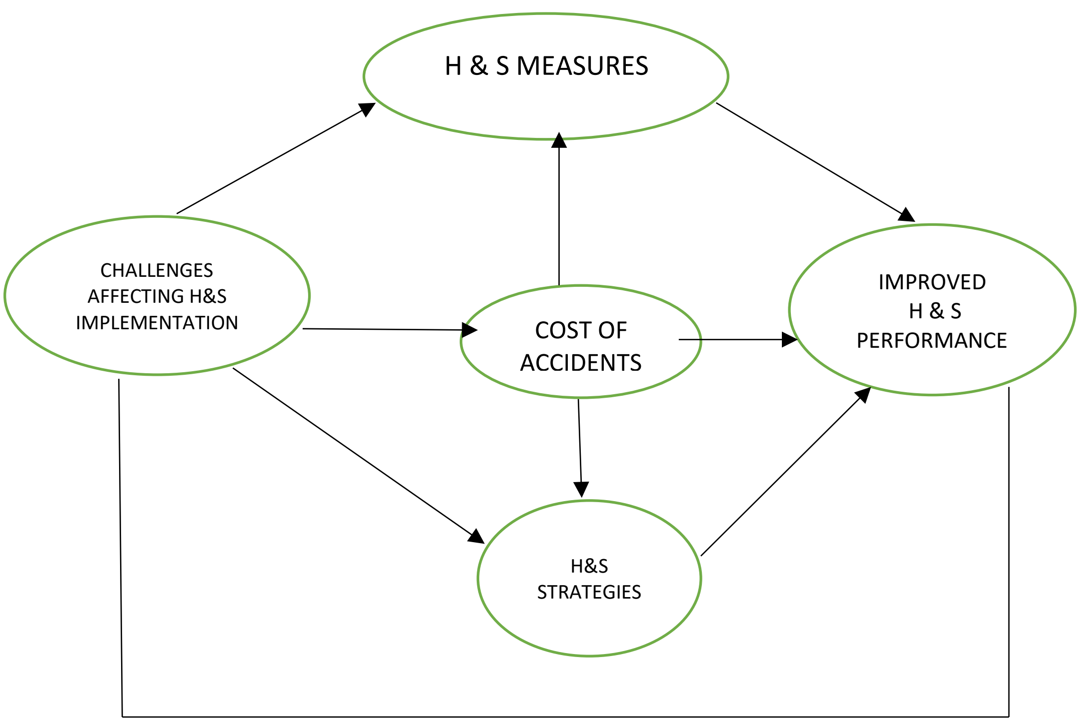

Figure 1: Conceptual framework for H&S measures implementation for construction SMEs

Source: Researchers Construct (2022)

Method of Data Analysis

The target population for this study constitutes the number of registered construction firms of small and medium sized medium sized categories (ISO certified) with corporate affairs commission (CAC) and Federation of Construction Industry (FOCI). The respondents include the Owners/managers, professional members and non-professionals, HSE personnel who are staff of the construction firms. A list of 3000 construction SMEs were obtained on 28th of October, 2021 from the most recent directory of the Corporate Affairs Commission of Nigeria after series of visit. The research design used for the study is the descriptive sample survey. The questionnaire as the main instrument for the study was administered to the contractors 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 on construction sites, challenges affecting the implementation of safety measures on construction sites by construction SMEs in Abuja and the strategies for improving the level of implementation of safety measures by construction 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 construction 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:

(1) It has the ability to accommodate constructs measured by a large numbers of variables (Abam & Nzeako, 2017)

(2) It allows for greater complexity within the model and can be used with non-parametric data;

(3) Sample size requirements are not as robust and dependent on power analysis for a determination of an appropriate sample size;

(4) It attempts to maximize variance explained in the latent variables through the relationship with the independent variables (Abam & Nzeako, 2017).

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 (Hair *et al.*, 2017).

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 (Chin, 1996; Hair *et al.*, 2014). Recent use of this method in the development and testing of hypotheses has become common in most social science research (Franke *et al*, 2019). As stated by Ali *et al.* (2018), 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 (Henseler *et al*., 2016) 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. (Truong & McColl 2011). Path relationships (correlational, one-way paths, or two way paths). These relationships are defined using arrows. Chin (2010) further reveals that structural equation model include two types of latent variables: Exogenous constructs: these are the constructs that does not have a predecessor. Endogenous constructs: these are the constructs that does have a predecessor.

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 (Chin, 1996; Hair *et al.*, 2014). Recent use of this method in the development and testing of hypotheses has become common in most social science research (Mojtahedu, 2015). As stated by Ali *et al.* (2018), 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 Wong (2013) and Ali *et al*. (2018) 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.

Furthermore, Ali *et al.* (2018) noted that PLS-SEM is the most popular SEM technique in various fields that has gained considerable attention. Its use is evident in business marketing (Hair *et al.*, 2012; Henseler *et al.*, 2009), e-business (Pavlou and Chai, 2002), management of organisations (Sosik *et al.,* 2009), international management (Richter *et al.,* 2016), management of human resources (Ringle *et al.,* 2019). In construction-related studies, PLS-SEM has equally gained significant recognition (Aghimien, 2020).

According to Wong (2013), besides the benefit of PLS-SEM is it has higher statistical power which is best to use in the exploratory study (Hair *et al*., 2017). 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. Here, the measurement model fixes the relationship between constructs and attributes while the structural model determines the relationship between constructs and unobserved variables (Ali *et al*., 2018; Wong (2013). 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 (Cepeda- Carrion *et al.,* 2018). However, some authors accept values ≤ 0.10 (Henseler *et al*., 2014).

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 constructs is assessed. It is suggested that R^2 for endogenous constructs should be greater than 0.1 (Falk & Miller, 1992). 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 (Hair *et al*., 2017). On the other hand, Ritchey (2008) 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 Falk and Miller (1992) rule by being above 0.1. However, the improved safety performance construct was considered the strongest, explaining 83.3% of the variance. See Figure 5.6 and Figure 5.7 for the structural model with path coefficients and R^2 and structural model with t-values respectively with respect to these discussions.

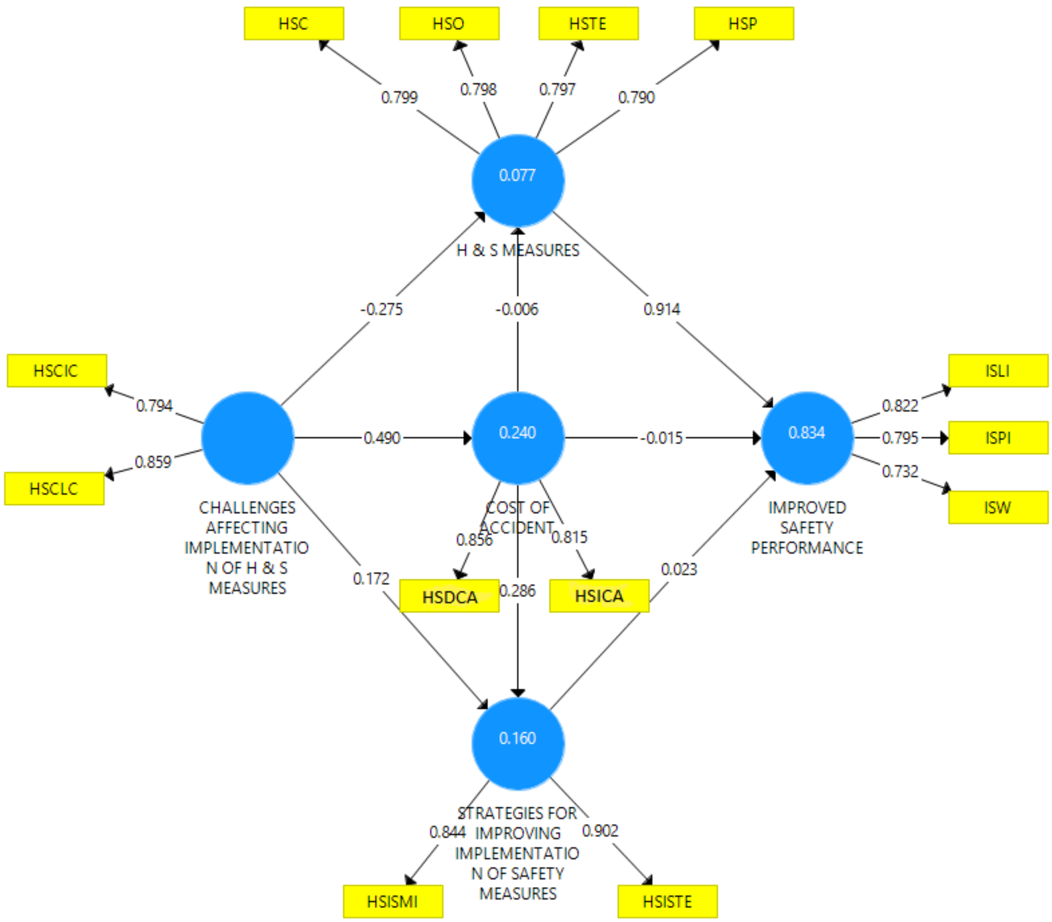

Figure 1: Structural Model with Path Coefficients and R^2

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, they all complied with Falk and Miller (1992) rule by being above 0.1. However, safety performance construct was considered the strongest, explaining 83.3% of the variance. Also 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 path (H1, H2, H3, H4, H8 and H9) were strongly significant and only three (3) path (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 be 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 AND RECOMMENDATIONS

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 clothing (PPC), 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 construction small and medium sized construction firms 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 safety measures on construction sites by small and medium sized construction firms.

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 statistical 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 construction SMEs in Nigeria can adopt the developed model to ensure effective implementation of safety measures to enhance safety performance in construction firms.

Recommendations

To ensure effective implementation of safety measures for construction SMEs in Abuja, Nigeria, the following recommendations are drawn from the conclusions of the study:

i. Construction firms should encourage and enhance the implementation/use of first aid kits, personal protective clothing (PPC) and safety policy as they have been identified as the effective safety measures required on construction sites 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 safety measures by construction SMEs. This study recommends that firms 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/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 safety measures will increase profitability by increasing productivity and uplifting employee confidence.

iv. This research recommend that construction firms 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 safety measure on construction sites by SMEs.

v. Organizations and construction stakeholders should encourage, ensure, and promote the proper implementation and adoption of the developed and validated model for safety measure implementation as it is intended to support small and medium sized construction firms 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 of small and medium sized construction firms in order to enhance firm's competitive advantage and boost performance.

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