



# Mitigating Recordable Incidents in Nigeria's Oil & Gas Construction Industry: A Human Factor Engineering (HFE) Approach

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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 Nigerian Oil and Gas construction industry poses significant risks due to incident prevention limiting factors. These factors include inadequate resource allocation, prioritization of production over safety, poor communication, insufficient supervision, suboptimal workplace design, weak risk perception, limited management commitment, worker incompetence, flawed design systems, and inadequate planning. This research aims to develop a human factor engineering model to support the reduction of the Total Recordable Incident Frequency (TRIFR) in Oil and Gas construction activities in Nigeria. The study involved site-based construction workers with a minimum of 2 years' experience in upstream, downstream, and midstream Oil construction industries. Data collection

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utilized a descriptive study design with structured questionnaires, and analysis employed SPSS-AMOS and Structural Equation Modelling (SEM) techniques. Results indicated statistically significant correlations between human factors and TRIFR across workplace, task, personal, organizational, and design factors. The structural equation regression model further demonstrated the significance of human factors in relation to TRIFR. Specifically, path coefficients of 0.18, -0.4, 0.31, -1.06, and -0.21 were observed for personal, organizational, workplace, design, and task factors, respectively. In conclusion, the research proposes that engineered human factors can effectively contribute to reducing the total incident frequency rate. Recommendations include the establishment of a construction safety board by the Nigerian government, the implementation of integrated contractor construction health and safety management systems by organizations and workers embracing personal responsibility for safety to prevent or minimize incident frequency rates.

*Keywords: Human factor engineering; risk assessment; total recordable incident frequency rate; oil and gas construction; Incident prevention.*

## 1. INTRODUCTION

Among the high-risk operations in Nigerian Oil and Gas industry is construction sub-sector with potentials for injuries or fatality to people (workers), damage to assets, environment and reputation if not adequately managed. Construction is project based and normally involve series of processes, events and interactions throughout the lifecycle of the project in a dynamic environment [1]. This process includes designs (concept development / conceptual design, front end engineering design, detailed engineering design), procurement, pre-mobilization, onsite and offsite fabrication, testing, finishing, load out, transportation (to onshore or offshore locations), erection and installation, pre-commissioning, commissioning and start-up and decommissioning phases [2]. All construction phases require human inputs, work case designs and management of human factor engineering processes. Oil and Gas construction industry in Nigeria is associated with numerous risk and factors [1]. Construction industry contributes greatly to Nigerian Gross Domestic Product (GDP), percentage growth (Agwu et al., 2014 & Tanko et al., 2017) and plays a significant role in economic growth of Nigeria as the sixth oil producer in the world with an oil reserve is about 36.15 billion barrels and the ninth oil producing nation in the world with a gas reserve of 203.16 trillion cubic feet (DPR, 2020). The Oil and Gas industry is one of the most profitable sectors in Nigeria that have contributed to technology advancement, poverty reduction and economic competitiveness. It is the largest foreign earner for the nation. It is confronted with diverse hazards with potential to result in accidents and diseases that creates human and economic burdens and have become

a concern to different governments around the world and international bodies like International Labour Organization [3].

Foreign construction companies were the first to start construction operations in Nigeria dominating the sub-sector due to incompetence and dwindling economic power of most indigenous construction companies [4]. This dominance has been cut down considerably as a result of improved government policies, technological transfer, adoption of public-private partnership, encouraging multicultural work model, improved training and political stability [5,6].

Human inputs play significant role in associated risk experienced in the Oil and Gas construction industry in Nigeria hence [7] disclosed that construction projects vulnerability accident casual factors include human factors, equipment, organizational, management, and environmental factors.

According to OGP [8]. Human Factors Engineering (HFE) is the application of human factors knowledge in designing socio-technical systems that optimizes the human contribution to production and reduces potential for design-induced risks to health, personal, process safety or environmental performance. Its primary aim is to optimize performance, reduce risk of operation and maintain good quality in an interacting complex system like Oil and Gas construction.

Top management commitment to safety plays an important role in reducing the frequency of accidents, Lost Time Injury Frequency Rate (LTIR) and Total Recordable Injury Frequency Rates (TRIFR) in the workplace and as well as reporting the incidents.

Accident rates in construction industry is higher than other sectors as revealed by statistics in other several countries (NBS, 2008) and further statistics show that workplace accidents is worse in developing countries than in developed countries [9].

The lost time incidents frequency reported by ILO [3] showed that about 2.3 million workers die every year from work related injuries and diseases which translates to 6000 deaths every day, 340 million occupational accidents, 160 million workers suffer from non-fatal work-related diseases, 313 million from non-fatal injuries per year and more than 4 per cent of the world's annual GDP gets lost as a result of work-related injuries and diseases.

Most organizations do not make safety a part of their business goals hence they do not provide adequate resources in managing safety in the workplace which contributes to high total recordable incident frequency rates experienced in the Oil and Gas construction industry.

This research will benefit the Nigerian government as huge losses (cost) associated with Oil and Gas construction accidents will be saved (prevented) resulting in increased revenue base of the country since Oil and Gas is a major income earner for the nation. This study also contributed to the development and improvement of safety regulations for proactive management of construction activities in Nigerian Oil and Gas industry. It will also reduce lost time incident frequency rates, improve wellbeing of workers, reduce cost and enhance productivity when the model proposed is implemented by the construction companies. The safety regulations that will result from this research will help in reinforcing safety practices in various Oil and Gas construction companies in Nigeria thereby resulting in improved workers' safety behaviour, reduced total recordable incident frequency rate and positive safety performance which are contributors to enhanced productivity and increased profitability.

## 1.1 Background

Reduction of total recordable injury frequency and lost time injury frequency rates is a primary objective for implementing human based safety controls in Nigerian Oil and Gas construction industry. Department of Petroleum Resources (DPR) report showed that 55 incidents took place in 2018 alone resulting in 77 fatalities of Nigerian

Oil and Gas industry workers DPR Report, [10]. The causes of these accidents have been attributed largely to unsafe acts and unsafe conditions triggered by failures in human factor engineering systems in the workplaces. This high rate of incidents can be reduced by adopting human factor engineering principles.

The sophistication of construction elements, relating to its social, human, and economic component, contribute to aggravating the situation and are responsible for its relatively high occupational injuries, according to Reyes et al. [11]. HSE can play a significant role in the prevention and abatement of major risk factors if HSE issues are incorporated throughout the lifecycle of project delivery.

Some of the negating features given by Haslam et al. [12] include poor risk evaluation, a high number of subcontracting partners, and unsatisfactory skills development. They proposed that by using precise techniques for identifying hazards, such as Task Risk Assessment (TRA), Hazard Identification (HAZID), and Hazard and Operability Study (HAZOP), these detrimental factors could be avoided and controlled in the design phase before they intensify and have an impact on the entire project.

## 2. LITERATURE REVIEW

Incidents in Oil and Gas construction sites can be fatal (Occupational Health and Safety Act, [13]. There are various reasons that contribute to this increase in incident especially in our Oil and Gas construction industry. Kvalheim et al., [14] Okoye et al., [15] Blackmon et al., [16] & Martin et al., [17] revealed that unsafe behaviours (human factor) contribute about 85% of occupational accidents which indicates that incidents do not just happen but are caused mainly by human factors either by what the workers do or failed to do in the workplace.

Department of Petroleum Resources (DPR) lost time injury frequency rate report showed that 55 incidents took place in 2018 alone resulting in 77 fatalities of Nigerian Oil and Gas industry workers DPR Report, [10]. The causes of these accidents have been attributed largely to human factor engineering system dysfunction in the workplace. Oil and Gas construction activities had a large ratio of this fatalities records.

According to OSHA (2020), one out of five deaths among United States workers is in the

construction industry and a total of 1,061 construction workers died on the job in 2019 U. S. Bureau of Labor Statistics, [18]. In each year, 9.7 of every 100,000 construction workers suffer a fatal injury. This is the fourth-highest rate of any industry and falls account for 33% of all construction deaths. Eliminating falls from height in construction operations would save more than 300 lives every year in the United States U. S. Bureau of Labor Statistics, [18] & BigRentz, [19]. The “Fatal Four” leading causes of construction deaths in the United States are falls, struck by equipment, caught in between, and electrocutions which accounts for over 60 percent of all construction-related deaths (OSHA,2020). Aksorn & Hadikusumo [20] revealed that accident causation in construction industry is related to the behaviour and actions of unsafe workers which represents the main factors causing these occupational accidents in construction industry. Other factors identified that have contributed to work-related accidents in construction industry included poor work design, lack of inspection procedures for work equipment, poor planning and use of sub-standard work equipment that do not comply with safety standards [21]. Organizational factors such as the lack of company’s commitment to safety Zou et al.,[22] lack of positive safety culture in most construction companies [23] non-existence of or poor consequence management system to support safety compliance [24] have also contributed to work-related accidents in Construction industry. Management factors such as lack of safety policy and its poor management where it exist both corporately and on site [25] as well as environmental factors such as bad weather and hazardous work environments such as high noise, poor illumination, exposure to radioactive materials, chemical laden and dust prone environments [21] have all contributed also. It is then known that increase in total injury frequency and lost time injury frequency rates are largely human factor dependent.

Nzelu [26] showed that communication constraints, distractions, resources constraints, task routine and complacency are among the reasons for the increase in total recordable incident frequency and lost time incident frequency rates in Oil and Gas construction industry. Okeke et al. [27] affirmed that rotational work which is a major characteristic of Nigerian Oil and Gas construction industry can be one of the major reasons that contributes to strain in families, marital, career and personal relations

which are precursors for incident causation in Nigerian Oil and Gas construction industry.

These total recordable injury frequency and lost time injury frequency rates are preventable since they are caused primarily by human factors. Preventive remedies for the increase in incident frequency rates include construction companies providing appropriate training or workers, effective communication among the teams and management. Other remedies such as adequate planning of jobs, use of only competent workers for high-risk operations, avoiding shortcuts, encouraging risk assessment methodologies on site could also prevent unforeseen increase in incident frequency rates. Encouraging workers to be involved in safety, placing priority on workers’ welfare on site, donning the appropriate personal protective equipment for the job, providing safe equipment and ensuring that the work environment is safe for workers to perform their duties are among the remedies that could lead to prevent increase in incident frequency in Construction industry.

### 3. METHODS

Structured questionnaire was deployed to collate data from population sampled from construction workers in Lagos (latitudes 6°23’N and 6°41’N and longitudes 2°42’E and 3°42’E), Port Harcourt (4°45’N605°E) and Warri (3°N600°E) during this study. Purposive sampling method was used due to availability of time, nature of the study, accessibility to the Oil and Gas construction companies and their activities which are not common in all cities and towns of Nigeria. Data collated from the research instrument (questionnaire) was computer processed using version 26 of statistical package for social science (SPSS) with AMOS and structural equation modelling techniques.

Pearson coefficient correlation, confirmatory frequency analysis, goodness of fit index statistics, Chi square, confirmatory frequency index (CFI), good fit index, (GFI), root mean square error of estimation (RMSEA), adjusted goodness of fit index (AGFI), P-value and standardized root mean square residual estimation (SRMRE) were used as inferential tests set at 0.05 and 0.01 alpha levels of significance. Sample population estimation was done using Cochran’s formula for calculating sample size when the population is infinite at a 95% confidence level with ±5% precision and this is given as

Equation 1: Cochran's formula for calculating sample size for infinite population at 95% confidence.

$$n_0 = \frac{z^2 pq}{e^2}$$

Structural equation modelling, a multivariate regression analytical tool was preferred for this study because its assumptions are clear and testable during analysis. Other advantages of using SEM techniques include:

- It's graphical interface software boosts creativity and facilitates rapid debugging
- It's regression coefficients, means, and variances may be compared simultaneously across multiple subject groups
- Errors can be purged easily using measurement and confirmatory factor analysis models
- It's ability to fit non-standard models and provides a unifying framework through which numerous linear models may be fit using flexible, powerful software [10].

The companies selected for this study are large Oil and Gas construction companies which are involved in Engineering designs, procurement, construction and installation (EPCI) operations both onshore and offshore. Each has a work force of over five hundred (>500) staff including short time employees and have multiple sites where construction activities were ongoing simultaneously.

#### 4. RESULTS OF THE STUDY

Pearson's correlational analysis was carried out to establish the relationship between the engineered human factors and total recordable injury frequency rate (TRIFR) and lost time injury frequency rate (LTIFR). From Table 1., the Pearson's correlation coefficient for workplace factor and LTIFR / TRIFR was 0.75, which was statistically significant (p-value < 0.000). The results showed that respondents that indicated not to have safe (ideal) workplace factor such as adequate workstation space and room temperature had reported high incidents and near misses rates during the course of their work. Responders with ideal workplace factor reported low incidents and near misses rates during the course of their work.

Pearson's correlation between LTIFR / TRIFR and task factor showed statistical significance

with a p-value of 0.004 and revealed that proper planning of task will result in low lost time frequency rate (LTIFR) and total recordable injury frequency rate (TRIFR) while poor planning will result in high LTIFR and TRIFR in Nigerian Oil and Gas construction industry.

The Pearson's coefficient correlation between personal factor and LTIFR and TRIFR was statistically significant with a p value of 0.001 and showed that workers that agreed to be confused or nervous about their task tend to contribute to high LTIFR / TRIFR while workers who agreed that they were not confused nor nervous while performing their task contributed to low LTIFR / TRIFR. Pearson Correlation coefficient between organizational factor and LTIFR and TRIFR was also statistically significant with a p value of 0.007. The result indicated that proper planning by management involving workers when planning on task procedures would lead to reduced LTIFR and TRIFR while not involving workers in the design of these procedures will result in high LTIFR and TRIFR. The Pearson's coefficient correlation between design factors and LTIFR and TRIFR also showed statistical significance with a p value = 0.000. This affirmed that involvement of qualified and competent worker in design process results in reduced LTIFR and TRIFR while incompetent designers and workers will result in high incidents rates

The relationship between human factor engineering and TRIFR / LTIFR was determined using a two-point model. Confirmatory factor analysis evaluated the reliability of the indicator variables used in measuring each construct while structural equation modeling tested the hypothesis of the study below.

**Null Hypothesis (H<sub>0</sub>):** There is no significant relationship between human factor engineering and occupational health and safety performance improvement in Nigerian Oil and Gas construction industry

**Alternative Hypothesis (H<sub>1</sub>):** There is significant relationship between human factor engineering and occupational health and safety performance improvement in Nigerian Oil and Gas construction industry

The result from the goodness of fit indexes as presented in Table 2. showed that the comparative fit index (CFI) had a test statistic of 0.90 which indicate a good fit according to Byrne

[28] who suggested that to obtain an adequate model, the CFI must be  $\geq 0.90$ . The Goodness of fit index (GFI) statistic was 0.913 which also indicated good fit accordingly to Whittaker [29] who suggested that GFI values greater than 0.90 indicate adequate fit. The adjusted goodness of fit also showed good fit with a statistic greater than 0.901. The Root Mean Square Error of Approximation was 0.028 which indicated a closely fitted model according to Kline [30] who suggested that RMSEA value less than 0.05 indicate a closely fitted model.

The regression weight for the measurement model as presented in Table 3. which provided evidence of the reliability of how each indicator variables accurately measures the latent construct showed that all the indicator manifest variables did a good job in predicting the latent construct and the confirmatory factor analysis. It also provided sufficient evident that the indicator manifest variables did a good job in measuring the latent variable of interest.

The structural equation regression model result as presented in Table 4. & Fig. 2 showed that the path coefficient from personal factor to TRIFR / LTIFR was 0.18 and was statistically significant

which means that increase in the nervousness by workers when performing their task will result to increase in TRIFR / LTIFR. The path coefficient for organizational factor TRIFR / LTIFR was - 0.40 was statistically significant and showed that increase in the organizational factor such as effective planning and safe system of work will result in reduction of TRIFR / LTIFR in Nigerian Oil and Gas construction sites while decrease in organizational factors will lead to high incident rates. The path coefficient for workplace factor to TRIFR / LTIFR was 0.35 which was statistically significant and showed that decrease in the deterioration of the workplace factor would lead to reduced TRIFR / LTIFR and increase in workplace deterioration will lead to increase in TRIFR / LTIFR. The path coefficient for design Factor and TRIFR / LTIFR was -1.05 which was statistically significant. This indicated that increase in the design factor such as engagement of competent designers will lead to reduced TRIFR / LTIFR and the use of incompetent designers will result in high TRIF / LTIF rates. While the task factor and TRIFR / LTIFR improvement path coefficient was -0.21 and indicated that increase in the task factor will result to reduced TRIFR / LTIFR.

**Table 1. Pearson correlation between the human factor engineering and LTIFR / TRIFR**

		WP	TK	PS	OG	DS	LTIFR /TRIFR
WP	Pearson Coff.	1					
	p-value	-					
TK	Pearson Coff.	0.116*	1				
	p-value	0.046	-				
PS	Pearson Coff.	0.041	.251**	1			
	p-value	0.485	.000	-			
OG	Pearson Coff.	-0.026	-.093	-0.130*	1		
	p-value	0.655	.110	.025	-		
DS	Pearson Coff.	-0.049	-.094	-0.137*	0.087	1	
	p-value	0.403	.107	0.018	.138	-	
LTIFR / TRIFR	Pearson Coff.	0.75**	-0.489**	0.437**	-0.48**	-0.209**	1
	p-value	0.0001	.004	0.001	0.007	0.000	-

\*. Correlation is significant at the 0.05 level (2-tailed).

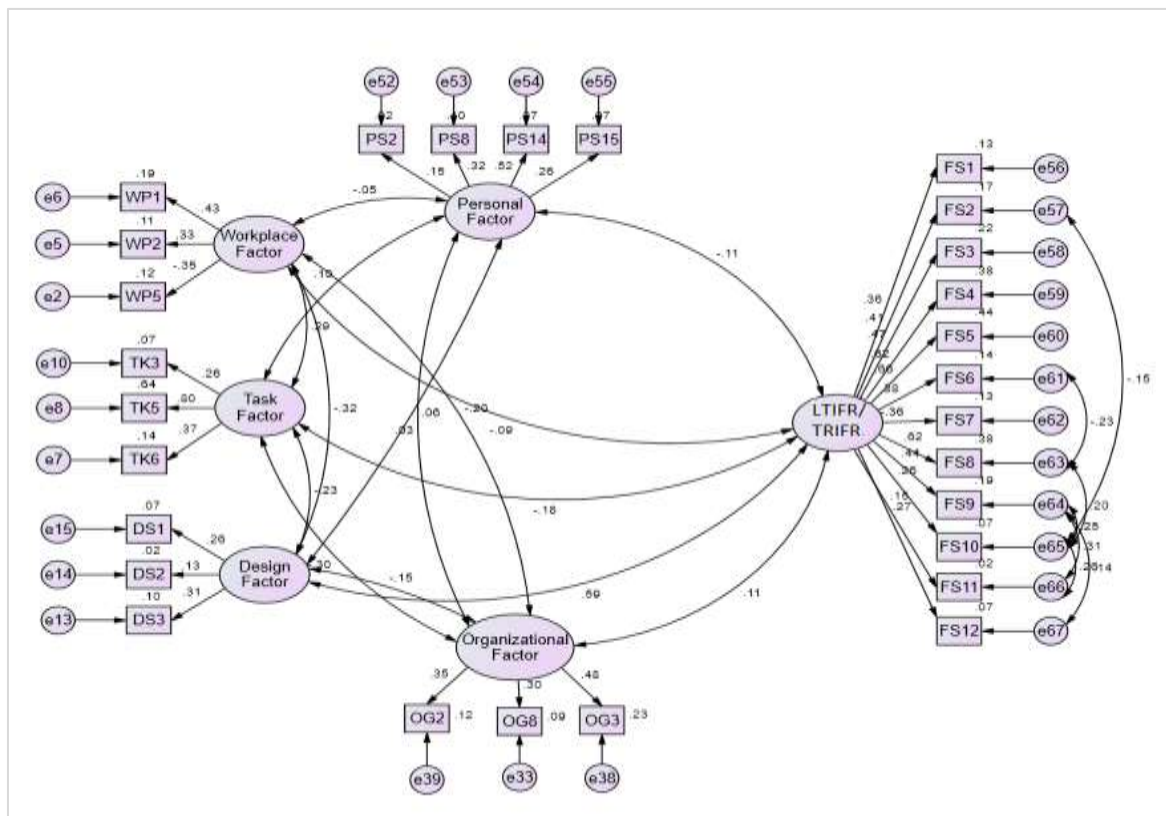
\*\* Correlation is significant at the 0.01 level (2-tailed).

**Table 2. Goodness of fit index statistic**

Goodness of Fit Statistic	Value
CFI	0.90
RMSEA	0.028
SRMSE	0.055
GFI	0.913
AGFI	0.901

**Table 3. Regression weight (unstandardized)**

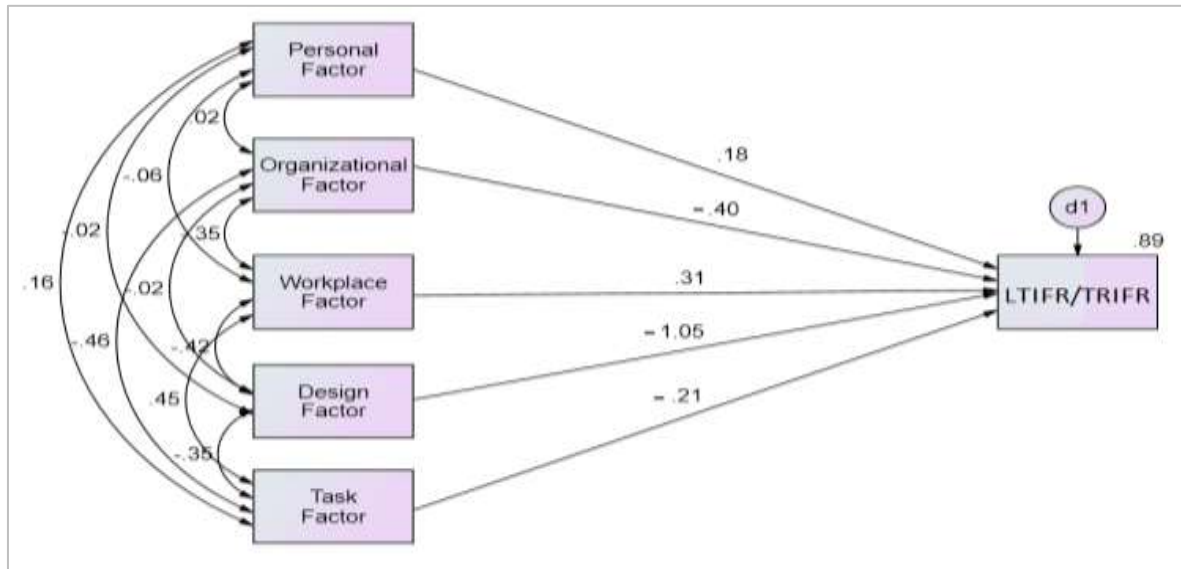
Latent factor to indicator variable			Estimate	S.E.	C.R.	P
TK5	<---	Task Factor	3.205	1.327	2.415	.016
TK3	<---	Task Factor	1.000			
DS3	<---	Design Factor	1.000			
DS2	<---	Design Factor	.413	.187	2.209	.023
DS1	<---	Design Factor	.844	.402	2.101	.036
TK6	<---	Task Factor	1.464	.470	3.112	.002
OG2	<---	Organizational Factor	1.000			
OG3	<---	Organizational Factor	1.337	.625	2.140	.032
WP2	<---	Workplace Factor	.785	.372	2.109	.035
WP1	<---	Workplace Factor	1.000			
WP5	<---	Workplace Factor	-.868	.410	-2.116	.034
PS2	<---	Personal Factor	.491	.375	1.310	.190
PS15	<---	Personal Factor	1.000			
PS14	<---	Personal Factor	1.929	0.975	1.978	.048
PS8	<---	Personal Factor	1.235	.631	1.957	.050
OG8	<---	Organizational Factor	.826	.376	2.194	.028
FS5	<---	LTIFR & TRIFR	1.589	.302	5.265	***
FS6	<---	LTIFR & TRIFR	1.064	.258	4.119	***
FS7	<---	LTIFR & TRIFR	-1.054	.257	-4.097	***
FS8	<---	LTIFR & TRIFR	1.536	.300	5.126	***



**Fig. 1. Measurement model for the relationship between human factor engineering LTIFR / TRIFR (Unstandardized weight)**

**Table 4. Unstandardized regression weight**

Path			Estimate	S.E.	C.R.	P
LTIFR & TRIFR	<---	Personal Factor	0.18	.036	-8.964	***
LTIFR & TRIFR	<---	Organizational Factor	-.40	.039	17.006	***
LTIFR & TRIFR	<---	Workplace Factor	.31	.030	13.052	***
LTIFR & TRIFR	<---	Design Factor	-1.05	.040	45.876	***
LTIFR & TRIFR	<---	Task Factor	-.21	.033	8.187	***



**Fig. 2. Relationship between human factor engineering and the LTIFR / TRIFR (Unstandardized regression weight)**

Table 5 showed the standardized regression weight and revealed that workplace factor had the highest standardized regression weight of 1.832 which made the design factor the most important predictor of LTIFR / TRIFR. Task factor had standardized regression weight of 0.272 which indicated that task factor was the least predictor of LTIFR / TRIFR in Nigerian Oil and Gas construction industry.

**5. DISCUSSION**

The increase in injury rates over the years in Nigerian Oil and Gas construction industry has become a concern for industry operators These increases are primarily caused by human inputs either what the workers do unsafely or what the workers refuse to do safely. The adoption of workers’ behaviour modification principles in our construction sites will aid in minimizing both the total recordable injury frequency and lost time injury frequency rates in Nigerian Oil and Gas construction industry. The consciousness of this human mind engineering in our construction sites is needed to maintain safety especially in Oil and

Gas construction industry in Nigeria and this is the essence of this research study.

According to Reyes et al. [11] construction industry is sophisticated and characterized by different components such as social, human and economic which tend to aggravates the unsafe work conditions and ultimately result in increased injury rates. This means that the Oil and Gas construction industry is high risk sector with workforce that contributes to its increased injury rates. The conscious engineering of the human factors involved in the Oil and Gas construction industry can lead to improved human behaviour and ultimately result in reduced total recordable injury frequency rate in our construction sites.

This research was evaluated using a two-part model. Confirmatory factor analysis (measurement model) evaluated the reliability of the indicator variables used in measuring each construct and structural equation modeling tested the hypothesis of the study. Also, a correlation analysis was done during this study.



**Table 5. Standardized regression weight**

			Estimate	S.E.	C.R.	P	Label
LTIFR & TRIFR	<---	Personal Factor	-.325	.036	-8.964	***	
LTIFR & TRIFR	<---	Organizational Factor	.663	.039	17.006	***	
LTIFR & TRIFR	<---	Workplace Factor	.395	.030	13.052	***	
LTIFR & TRIFR	<---	Design Factor	1.832	.040	45.876	***	
LTIFR & TRIFR	<---	Task Factor	.272	.033	8.187	***	

Pearson's coefficient correlation between workplace factor and LTIFR / TRIFR was 0.75 and statistically significant with a *p*-value of 0.0001. This shows that unsafe workplace will result in increase in accident and ultimately increase in both total recordable injury frequency rate and lost time injury frequency rate. Pearson coefficient correlation between task factor and TRIFR was -0.49 and statistically significant with a *p*-value of 0.004. This revealed that proper planning of task prior to starting work will result in a reduced TRIFR in Nigerian Oil and Gas construction companies and vice versa. Pearson's coefficient correlation between personal factor and TRIFR was 0.44 and was statistically significant with a *p*-value of 0.001. This revealed that confused workers or those that work under tension are prone to increased accident rate and invariably high rate of TRIFR in Nigerian Oil and Gas construction industry vice versa. The research result showed that the Pearson correlation coefficient between organizational factor and TRIFR was -0.48, and was statistically significant with a *p*-value of 0.007. This result means that adequate planning by management and consciously involving workers during design of Oil and Gas construction in Nigeria result in reduced TRIFR and LTIFR on sites. The Pearson's coefficient correlation between design factors and TRIFR and LTIFR was -0.21 which was statistically significant with a *p*-value of 0.000. This showed that using qualified personnel in the design process will result in reduction in TRIFR and LTIFR in Nigerian Oil and Gas construction industry. CFA (measurement model) was used to evaluate the reliability of the indicator variables used in measuring each construct and structural equation modelling was used to test the hypothesis of the study during this research. The CFI had a test statistic of 0.90 which indicated a good fit according to Byrne [28] who suggested that to obtain an adequate model, the CFI must be greater than 0.90 and to obtain a superior model, CFI must be greater than 0.95. The GFI statistic was 0.913 and indicated good fit in tandem with the suggestion made by Whittaker

[29] that GFI values greater than 0.90 indicate adequate fit while GFI values greater than 0.95 indicate superior fit. The adjusted goodness of fit index obtained from the measurement model also showed good fit as the AGFI was greater than 0.901. The Root Mean Square Error of Approximation for the measurement model was 0.028 which indicated a closely fitted model. Kline [30] suggested that RMSEA value less than 0.05 indicate a closely fitted model and values less than 0.10 indicate an adequate fit but warned that values greater than 0.1 indicated that the model have problem with its specification. These criteria proved that the data collated fitted the model developed for the safe operations of construction activities in Nigerian Oil and Gas industry.

The confirmatory factor analysis result showed that the manifest indicator variables measuring the latent construct had standardized regression weight greater than 0.5 which disclosed a good job in measuring the latent variable of interest, in other word they are reliable.

The structural equation modelling result showed that the path coefficient from personal factor to lost time injuries frequency and total recordable injuries was 0.18 and statistically significant. This showed that increase in the nervousness by workers when performing their task will result to increase in accident rate leading to increase in lost time injuries frequency and total recordable injuries frequency in Nigerian Oil and Gas construction industry. This means that an increase in the nervousness by workers when performing tasks by 1 unit will lead to a 0.18unit increase in accident rate which increase the lost time injury frequency rate and total recordable injury frequency rate. Organizational factor and total recordable injuries frequency path coefficient was -0.40 and was statistically significant. This means an increase in the organizational factor by 1 unit will result to a 0.40-unit reduction in the LTIFR and TRIFR, lost time injury frequency rate and total recordable injury frequency rate, vice versa.

Zou et.al., [22] revealed that organizational factors such as lack of company's commitment to safety is a contributor to accident causation, lack of positive safety culture in most construction companies according to Choudhry et.al, [23] also contributes to accident, non-existence of or poor consequence management system to support safety compliance as revealed by Lingard and Rowlinson. [24] management factors such as lack of safety policy and its poor management where it exist as shown by Tam et.al., [25]. All these human factors could be engineered resulting in low lost time injury frequency and total recordable injury frequency rates in accordance to research objectives and outcome.

Workplace factor and lost time injuries frequency had a pathway of 0.31 which was statistically significant. This showed that an increase in 1-unit deterioration of the workplace factors will result to a 0.31 increase in lost time injury frequency rate and total recordable injury frequency rate. The path coefficient for design factor and total recordable injury frequency was -1.05 and was statistically significant. This showed that an increase in the engineered design factor such as use of competent designers by 1 unit will lead to a 1.05-unit reduction in total recordable injury frequency in the Oil and Gas construction sites in Nigeria. According to Romero et. al, [21], poor work design is one of the factors that contribute to work-related accidents in Oil and Gas construction industry, hence if the human factor is engineered, accidents will be prevented according to the outcome of this research. According to Romero et.al, [21], high noise, poor illumination, exposure to radioactive materials, chemical laden and dust prone environment are contributory factors to accident in the Oil and Gas industry but when tweaked using human factor engineering strategies as revealed in this study, accidents could be prevented or reduced to as low as reasonably practicable. This will ultimately result in low TRIFR and LTIFR.

Task factor and lost time injury frequency rate and total recordable injury frequency rate path coefficient was -0.21 which showed that an improvement in work designs by 1 unit will result to a decrease in lost time injury frequency and total recordable injury frequency by 0.21 units. Design factor had the highest standardized regression weight (1.832) which proved that it the most important predictor of lost time injury frequency rate and total recordable injury frequency rate in Nigerian Oil and Gas

construction industry while task factor is the least predictor with a standardized regression weight of 0.272. Lack of inspection procedures for work equipment, poor planning and use of sub-standard work equipment were identified as accident causative factors in the Oil and Gas construction industry [21]. Hence, when these factors are engineered, they could prevent accidents in the Oil and Gas construction industry which is one of the outcomes of this study.

Research conducted by Reader et al. [31] showed that management commitment to safe task practices both within the workplace and projects have impact on workers behaviour, increases their skills and ultimately results in safety performance improvement.

Pearson's correlation coefficient between design factor and safety performance improvement was 0.426, which was statistically significant (p value = 0.002). This showed that using qualified personnel in design process increased positive safety performance while incompetence and inappropriate definition of roles in Oil and Gas construction in Nigeria will result in poor safety performance.

The confirmatory factor analysis as a measurement model was used to determine the reliability of the variables and how fit the data was to the model. goodness of fit analysis was done with different parameters considered in determining the fitness of the model. The study shows that the comparative fit index (CFI) had a test statistic of 0.910 which indicated a good fit because Byrne [28] suggested that to obtain an adequate model, the CFI must be greater than 0.90. The goodness of fit index (GFI) statistic was 0.944 which also indicated good fit because Whittaker [29] suggested that GFI values greater than 0.90 indicate adequate fit. The adjusted goodness of fit index (AGFI) obtained from the measurement model also showed good fit as it was greater than 0.9. The Root Mean Square Error of Approximation (RMSEA) for the measurement model was 0.021 which indicated a closely fitted model in tandem with Kline [30] suggestion that RMSEA value less than 0.05 indicates a closely fitted model. The goodness of fit analysis therefore indicated that the data collated for the study was reliable and have good fit to the model [32,33].

The skewness obtained from the study ranged from -1.181 to 0.956 which showed that the

human engineered factors were normally distributed since normality of variables is one of the assumptions that must be satisfied in structural equation modelling. The result of structural equation modelling showed that the path coefficient from personal factors to safety performance improvement was -0.89 and was statistically significant which means that decrease in nervousness of Nigerian Oil and Gas construction workers by 1 unit resulted in 0.89-unit improvement of safety performance [34,35].

The path coefficient for organizational factor and safety performance was 2.630 which was statistically significant. The result showed that increase in the organizational factor by 1 unit will result to a 2.63unit increase in the safety performance and vice versa. This study showed that when appropriate and adequate training is given to Oil and Gas construction workers in Nigeria prior to assigning task to them, safety performance is enhanced. The research also reveals that safety performance increased as a result of workers' consultations prior to development of procedures in Nigerian Oil and Gas construction industry [36].

The path coefficient for workplace factor of safety performance was -1.591 which was statistically significant. The result implies that 1 unit increase in the deterioration of the workplace factor will result to a 1.59 decrease in the safety performance. The result of the research showed that increase in high temperature of the construction sites resulted in a corresponding decrease in safety performance of the workers in Nigerian Oil and Gas construction sites.

The path coefficient for design Factor and safety performance was 4.645 which was statistically significant. The result gives indication that increase in the design factor by 1 unit will lead to a 4.65unit improvement in safety performance. The result reveals that when competent designers are involved in the process of Oil and Gas construction designs in Nigeria, safety performance is enhanced.

The task factor and safety performance path coefficient was 0.492. which gave an indication that increase in the task factor by 1 unit will result to an increase in the safety performance by 0.49 units. The research further revealed that construction workers having access to up to date and clear safe system of work contributed to safety performance on site.

The result revealed that workplace factor was the most important predictor of safety performance improvement as it had the highest relative standardized regression weight (-1.016) while task factor was the least predictor of safety performance having a standardized regression weight of 0.204. According to Hofmann and Morgeson's (2009), employee's impression of safety at work is influenced by their view of the organization's commitment to their safety at work (organizational attitude towards safeness) and safety environment which significantly influence workers safety performance in the workplace.

## 6. CONCLUSION AND RECOMMENDATIONS

Oil and Gas construction incidents can be prevented when adequate and appropriate training is provided to the workers, only competent workers are hired and placed according to their capacities, equipment are inspected as when required, planned preventive maintenance are done as deemed appropriate, risk assessment and job safety analysis are carried out by competent workers, health surveillance and fitness for duty test are effectively carried out, psychosocial stability is ascertained, management commitment to safety is reinforced and demonstrated on site, adequate resources are provided on site for construction safety management and adequate rest breaks observed on site. Reduction of incident rate and severity of its consequences will ultimately lead to reduction in total recordable injury frequency rate and lost time injury frequency rate in Nigerian Oil and Gas construction industry.

The government should establish a construction safety board with Oil and Gas construction sector as a division and populate it with highly competent professionals that will regularly carry out safety inspections, audits and oversights nationwide. Violations of health and safety regulations should attract fines, forfeited of operating license and imprisonment. This will contribute to reduction in injury frequency rates as accident rates are reduced. Organizations should set up integrated contractor health, environment and safety management system that helps them take care of safety in construction projects and hire competent workers to manage it thereby creating an incident and injury free workplace. Construction workers should own safety as a personal value ensuring that they don't get injured at work neither injure their co-workers. Incident prevention in our Oil

and Gas construction sites is possible if all the parties keep to their own bidding in accepting responsibilities. Once, there is focus on incident prevention, injury frequency rates will drastically reduce making Nigerian construction sites safe, productive and profitable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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