JOURNAL OF MULTIDISCIPLINARY & TRANSLATIONAL RESEARCH

Journal of Multidisciplinary and Translational Research (JMTR)

journal homepage: https://journals.kln.ac.lk/jmtr/

Development of human factor engineering model for safe management of oil and gas construction industry

Thomas Daniel Obioma[1*], Nwaichi Eucharia Oluchi[2], and Patricks Chinemerem[3]

[1]Center for Occupational Health, Environment and Safety, University of Port Harcourt, Nigeria
[2]Department of Biochemistry, Faculty of Science, University of Port Harcourt, Nigeria
[3]Academic Planning, Research & amp; Control Unit, University of Port Harcourt, Nigeria

Abstract

The management of occupational health and safety within Nigeria's oil and gas construction industry in Nigeria is challenged by numerous factors, including limited resource allocation, the prioritization of production over safety, communication gaps, inadequate supervision, substandard workplace design, poor risk perception, low management commitment, worker incompetence, and deficient planning, all predominantly human-related. This study focuses on the development of a Human Factors Engineering (HFE) model to enhance the safe management of the oil and gas construction sector. Data were collected through structured questionnaires (n=295), and descriptive analyses were conducted using SPSS Version 26 with AMOS. A conceptual model for HFE was initially formulated, followed by the study and adaptation of the International Association of Oil and gas Producers' HFE framework to create a model tailored to the Nigerian context. Engineered human factors foster safe behavior, attitudes, processes, and systems, thereby promoting safer construction workplaces. Conversely, failure to engineer these factors often results in unsafe practices, leading to workplace accidents and significant losses. To ensure the successful adoption of the developed model, it is recommended that the Nigerian government actively integrate it into industry practice through robust regulation. At the same time, oil and gas construction companies should incorporate the model into their planning and continual improvement of safe systems of work to enhance overall workplace safety.

Keywords: Human factor engineering model, loss prevention, occupational health and safety management, oil and gas construction, risk engineering

Article info

Article history:
Received 11th February 2026
Received in revised form 28th April 2026
Accepted 25th May 2026
Available online 19th June 2026

ISSN (E-Copy): ISSN 3051-5262
ISSN (Hard copy): ISSN 3051-5602
Doi: https://doi.org/10.4038/jmtr.v11i1.105
ORCID iD: https://orcid.org/0000-0001-6514-9170
*Corresponding author:
E-mail address: dantomr70@gmail.com (Thomas Daniel Obioma)

Introduction

The process of construction involves putting together diverse parts in accordance with a detailed design and plan to create a structure meant for a particular place, purpose, and usage. oil and gas construction activities are always transient and involves a series of processes, events, and interactions in a dynamic environment (Fadun and Saka, 2018) that includes different design layers, procurement, pre-mobilization, on-site and off-site fabrication, testing, finishing, load-loadout, transportation, erection and installation, pre-commissioning, commissioning and start-up phases, and decommissioning (Muyiwa & Sadeghi, 2007). Construction activities are inherently high-risk with possibilities for injuries or fatality to workers, damage to assets, environment and reputation when not well managed. The Gross Domestic Product (GDP) of most nations, including Nigeria, is largely dependent on construction (Oladinrin et.al., 2012; Okoye et.al., 2018). Nigeria's dependence on oil and gas revenues for its annual budget is substantial, and workers are in the mainstream of oil and gas production in Nigeria. According to Rosmariani et al (2019), construction accident causal factors include human factors, equipment, organizational, management, and environmental factors.

The concept of human factors engineering involves the application of certain 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 (Leva et.al., 2015) The major aim of human factor engineering is to optimize performance, reduce risk of operation and maintain good quality in an interacting complex system such as oil and gas construction. The high incident rate in the construction industry globally has been attributed to human error or violations.

This means that unsafe acts and conditions created by humans in the workplace are major contributory factors to most incidents in the construction industry, especially in the oil and gas sector. Organizational safety culture is a culmination of individual workers' behavior over time. Investigation of the 2005 Bruncefield oil storage explosion in Hertfordshire revealed that lack of safety implementation (i.e., organizational safety negligence) at the construction design stage, where a fuel escape safety device was not installed, was a major causative factor for the accident (HSE, 2011). This root cause validated the fact that oil and gas construction incidents are caused by unsafe acts or inactions of workers.

Over 80% of all occupational accidents and diseases in the workplaces, including oil and gas construction sites, are caused mainly by human (worker-related) factors, either by what the workers do or fail to do at work, which eventually result in organizational safety memory (Blackmon and Gramopadhye, 1995) and (Matias et.al., 2009). High incident rates in the oil and gas construction industry are contributed by inadequate provision of resources, which is practical evidence that most organizations do not make safety part of their business goals.

First, the Nigerian government is primarily meant to benefit from this research by saving the cost of accidents from the oil and gas industry. Other benefits of this research include the development and improvement of safety regulations, especially in the oil and gas construction sub-sector, improving the wellbeing of workers, reducing cost, and enhancing productivity as organizational safety culture is entrenched among the oil and gas construction companies in Nigeria.

Mechanisms for the prevention of incidents, such as human factor engineering processes in Nigerian oil and gas construction sites, do not receive adequate attention despite great consequences resulting from preventable accidents in the sites. This is due to other conflicting sectors and factors such as quality, cost, production, insufficient communication, perceived budget viability, and pressure to produce more, among others (Kashwani and Nielsen, 2017).

In Great Britain, 40 fatalities and 61,000 non-fatal injuries to workers occurred each year in the construction industry from the year 2019 – 2020 (HSE,2020).

These accidents on construction sites leading to different severities of consequences are majorly caused by unsafe behavior of workers, inadequate supervision, poor workplace design, not following safe systems of work, lack of management commitment to safety, use of defective tools, incompetence of workers and management negligence, among others, which summarizes human factor elements associated with the accidents. Accident causation factors in our construction sites have been attributed mainly to organizational factors such as lack of organizational commitment to safety (Zou et.al., 2008).

Lack of positive safety culture in most construction companies (Choudhry et.al.,2009), non-existence of or poor consequence management system to support safety compliance (Lingard and Rawlinson, 2004), and management factors such as lack of safety policy, including its poor management where it exists (Tam et.al., 2004). Nigerian oil and gas construction industry is faced with numerous human factor problems such as poor workplace conditions that contribute to poor safety performance, poor perception of safety which is rooted in poor safety attitude that translates into poor safety behavior leading to poor safety culture in the construction companies.

This research is primarily meant to benefit the government of Nigeria by reducing the costs associated with workplace accidents from oil and gas construction industry. Encouraging the development and improvement of safety regulations especially in the oil and gas construction sub-sector, improves the wellbeing of workers, reduces the cost and enhances the productivity since the organizational safety culture is entrenched among the oil and gas construction companies in Nigeria.

Construction and exploitation workers (those in mining) account for over 6 per cent of the people employed in the oil and gas sector **(**ILO & Graham, 2010). Workers in the oil and gas industry conduct physically demanding duties, such as putting up rigs, welding pipes, or constructing the infrastructure for refineries.

The rapid industrialization and rise in the complexity and size of construction projects, especially in the oil and gas industry, have contributed to maintaining top spot among the high-risk industrial sectors globally. Construction sites are notable for high rates of accidents resulting in fatalities and many other damages due to large number of workers involved, modern construction techniques used, use of big and bulky plants, numerous materials and machinery used, different operational protocols, myriad and trans-disciplinary elements of its workforce, hence sustaining safety on the job is one of the issues faced by the construction industry, especially projects of a large scale (Elsebaei et.al., 2020). Development of infrastructure for the oil and gas (both inland and offshore), whether they are powered energy sources (traditional, recyclable, or nuclear), industrial, manufacturing industries, water, and environmental activities, they are significant area of the technical development sector generally (Alison-Madueke, 2012). But there are some relative distinctions between oil and gas construction work and other construction industries, and (Alison-Madueke, 2012) has outlined these distinctions in the areas of management, diversity, collaboration, stakeholder mapping, strategic planning, and management of human resources efficiency, manufacturability, and contingency theoretical aspects.

As long as man has been, construction activities have existed as humans continually seek to improve their well-being and standard of living. The construction business seems to have greater exposure to workplace vulnerabilities than other industries due to the variety of construction elements such as social, human, and economic components. At the very least, there has to be interaction between the environment, tools, and personnel for construction processes to be undertaken.

To better understand these interactions, Thomas et.al. (2002), identified four main points of contact with exploration and production construction activities in the workplace, and they include;

1. Tangible, structural, and desk equipment interfaces including software units.
2. Management solutions interfaces such as information and communication practices, Organizational and operational variables, control of knowledge transfer, and effective human management.
3. People-related interfaces such as communication, partnership, team performance, and intellectual issues
4. Work-environment links are largely focused on the physical atmosphere (emission, loud sounds, heat, and motion), workspace pattern, space utilization and configuration, and environmental standards that affect human performance, health, and general wellbeing.

Understanding how individuals interact with other components of complex systems, such as the conception and evaluation of enterprises, activities, occupations, and tools, settings, items, and societal systems that constitute each work paradigm, is the main goal of human factors research as revealed by (OGP, 2011). According to OGP, (2011), the five sociotechnical elements of human factor engineering include work organization, equipment, environment, work, and the people.

Human factor engineering emphasizes the human resource component for strategy implementation (Lehto and Landry, 2012) because most workplace designs focus more on process efficiency than people. The result of HFE operations, according to Robb and Miller (2012), is an architecture that streamlines operational tasks, aids relief operations, and improves contextual perception for those employees engaged in operating rooms' tasks, facilities, and perhaps various sections of the operating facility.

At every stage of oil and gas construction project, risk is a major factor which (Akintoye and MacLeod,1997) described as being embodied by the concept of "volatility" that leads to uncertainty in the project's end price, length, and overall value. Effective risk identification, assessment, and control are essential for achieving project objectives and ensuring safe project delivery. The human component must be thoroughly comprehended, and information should be utilized more widely if the incidence frequency of risk components is to be reduced (Thomas et.al., 2023).

Arinee et.al. (2021) reported that maintaining workers' mental well-being and safety awareness remains a persistent challenge for construction organizations.

An accident inquiry technique called the Human Factor Analysis and Classification System (HFACS), based on Reason's (2000) Swiss cheese framework predicated on active and inert failure principles, is used to identify the causes of accidents in order to prevent reoccurrence. HFACS paradigm, system breakdowns can occur at 4 different levels, including employee dangerous behavior, unsafe or ineffective management, conditions that lead to unsafe behavior, and organizational failures (Wiegmann and Shappell, 2001).

This also suggests that accident-causing elements have a cascading impact, and accidents are inevitable if neither of the chain components is eliminated or regulated. Inefficient resource organization, poor asset architecture, suboptimal human capacity building, and organizational shortcomings are examples of common inherent system inadequacies, whereas risky activities like noncompliance and human mistakes that directly contribute to the occupational incident are examples of active failures (Hulme et.al., 2019).

Human Factors Integration Process (HFIP) is a systematic approach for integrating Human Factor (HF) into the service life of system design and analysis. Effective implementation of HFIP enhances optimum defense, implementation capabilities, and supports the sustainable growth of the system's technological and human components (RISSB, 2018). HFIP is extremely proactive, dynamic and a crucial step in the design and development process; as a result, it facilitates achievement of design outcomes (ISO, 2010).

(RISSB, 2018), demonstrated that the effective integration of technical and interpersonal factors contributes significantly to design optimization in the oil and gas construction industry.

According to ISO (2010), the quality of HFIP should be maintained by,

- Ensuring that thorough evaluation of HF concerns and their countermeasures are in place from the project feasibility stage, the asset's useful life, and extending to closure.
- Design uses an integrative methodology.
- The scheme prioritizes the needs of the end system administrator and employs a "recursive design philosophy" while effectively integrating methodologies, tools, approaches, and data for better utilization.
- It supports the key players in the system's overarching quality assurance system

Before conducting a detailed investigation of human factor contribution to unsafe occurrences, it is essential to understand the positional contribution of human error within the workplace incident occurrence chain. A comprehensive examination of erroneous risks, analysis of related regulatory mechanisms, and identification of possible flaws and possibilities for enhancement within the preventative and mitigating lines of protection may all be facilitated by correctly locating error in the sequence of events (OGP, 2011). Human factors research analytical tools can be used in this kind of investigation. It is typical to employ the HF investigation toolbox to assist with this procedure (Energy Institute, 2008).

Human performance enhancement technology (HPET) is the willingness to support some aspects of the physiological functions of the human body in oil and gas construction workplace. Personal improvement, or the enhancement of one's physical and cognitive capacities, has long been a goal for mankind (Wolbring, 2009). Even though the risks connected with these innovations have been previously considered to be modest, they might be classified as growing risks to individual wellbeing and should be properly considered (Keulartz and van den Belt, 2016).

There is significant opportunity for implantable surveillance to improve health of construction workers. Device for personal protection and athletic efficiency has been developed and made accessible for acquisition. Even healthcare experts like physicians and other specialists have indicated a great interest in using Augmented Reality (AR) glasses while doing surgery (Giger and Gaspar, 2019).

According to Sandberg and Pinnington (2009), enhancing functionality level was a sort of interference that might either create new bodily functions that don't ordinarily exist or raise the level of functionality of certain already-existing ones. This is consistent with the views of some scholars (Tamara Garcia and Ronald Sandler) (who thought that automation may improve some of the basic human functions or give people new and different talents (Hess and Winner, 2007) and (Thomas et.al., 2025).

Reliability as a discipline essentially aims to minimize or fully eliminate the necessity for on-going modifications and maintenance. The relationship between the core workplace resources people (the most valuable organizational asset), tools, and operations is highlighted by the reliability principle (Energy Institute, 2012). Similar to systems reliability, human reliability aims to guarantee that the most valuable organizational asset is in a comparatively improved shape to maintain, all else being equal, optimal performance within the workplace (Energy Institute, 2012).

Energy Institute (2012), enumerated the fundamental Human reliability assessment steps to include:

i. Preparation and issue description.
ii. Job analysis.
iii. Determination of human failure.
iv. Human error simulation.
v. Characterization of human failure.
vi. Impact evaluation.
vii. Failure minimization
viii. Review

Analytical techniques such as failure mode and effect analysis (FMEA), Preliminary Hazard Analysis (PHA), Failure Modes, Effects and Criticality Analysis (FMECA), Technique for Human

Error Rate Prediction (THERP), and Performance-Shaping Factors (PSFs) can easily be used to detect a device or key failure mechanisms of an operation.

The constituents of a device, their possible failure configurations, the probability and implications of each breakdown, as well as the established and prospective mitigation strategies that may be taken to avoid the failure or its impacts, are all listed on spreadsheets generated for each of those techniques (Hammer, 1993).

Understanding accident causation principles and properly classifying the contributions of various elements to the accident, including human marks the beginning of purposeful accident prevention study. Human factors are a wide variety of components that affect how the workforce interacts with the work setting and some have no obvious negative effects but are clear and easily measurable characteristics of how labor systems operate. In the oil and gas construction industry, some of the factors that contribute to occurrences in occupational safety include

- Pre-condition for unsafe act, temporal detachment, optical distortions, oxygen deprivation, ailment, misuse of drugs, lack of innate talents, incompetence, and other potential therapeutic and clinical anomalies that are known to impair efficiency.
- Human error and unsafe actions, including contraventions
- Poor supervision of the workplace and the workers.
- Organizational failures in terms of managerial mistakes which has serious impact on all strata of the organization
- Organizational principles such as control and command are used in emergencies

Typical stages and activities in an oil and gas construction project include designing (conceptual, Front End Engineering Design, FEED, engineering), purchasing, pre-mobilization, fabrication, configuration screening (hydro, and Non - destructive tests), finishing (blowing, painting and glazing), stockpile out, haulage to location (near-shore or offshore), assembly, commissioning, operation, delivery, decommissioning and star-up stages as seen in the Figure 1

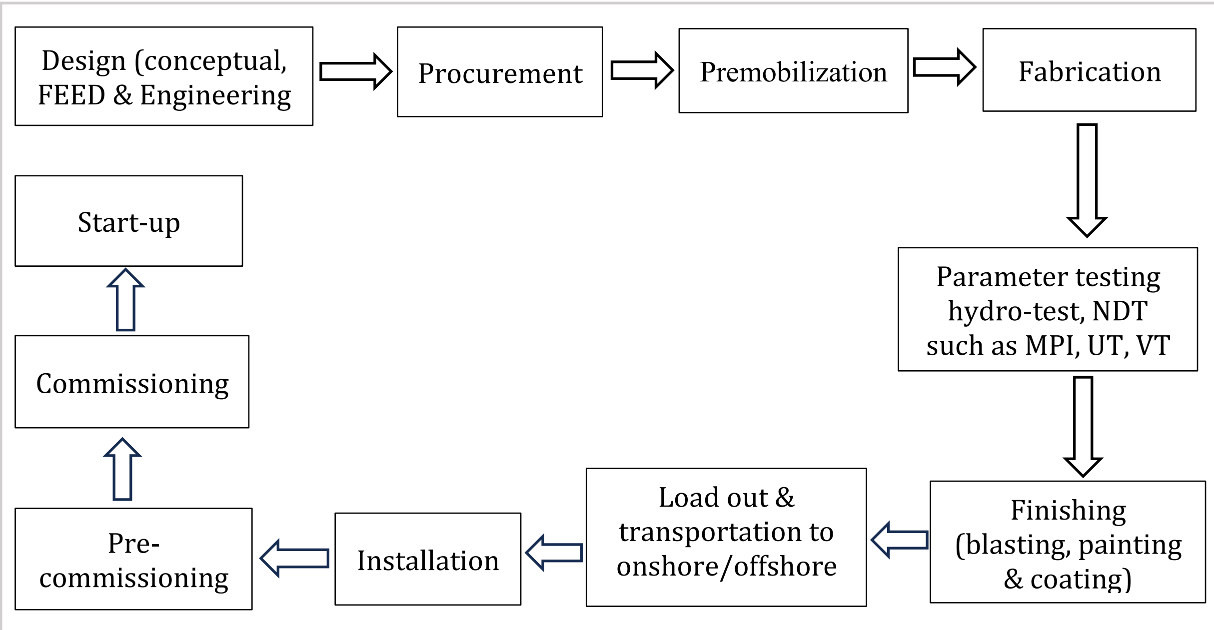

Figure 1. Oil and gas construction process/flowchart

Figure 2 showed a conceptual model debiting the interrelationship between human factors and construction processes in the Nigerian oil and gas industry. When human factors such as design, personal, organizational, workplace and personal factors are engineered during any of the oil and gas construction process (such as design, purchasing, pre-mobilization, fabrication, configuration screening, finishing, stockpile out, assembling, commissioning, operation, delivery and decommissioning stages), the immediate outcome becomes safe behavior, processes, systems and culture which ultimately results in loss prevention in oil and gas construction industry. On the other hand, when these human factors (such as design, personal, organizational, workplace and personal factors)are not engineered during decommissioning)In construction processes (design, purchasing, pre-mobilization, fabrication, configuration screening, finishing, stockpile out, assembling, commissioning, operation, delivery, and decommissioning), the immediate resulting effects would be unsafe acts, systems, processes, and culture that have a high propensity for accidents, leading to diverse losses.

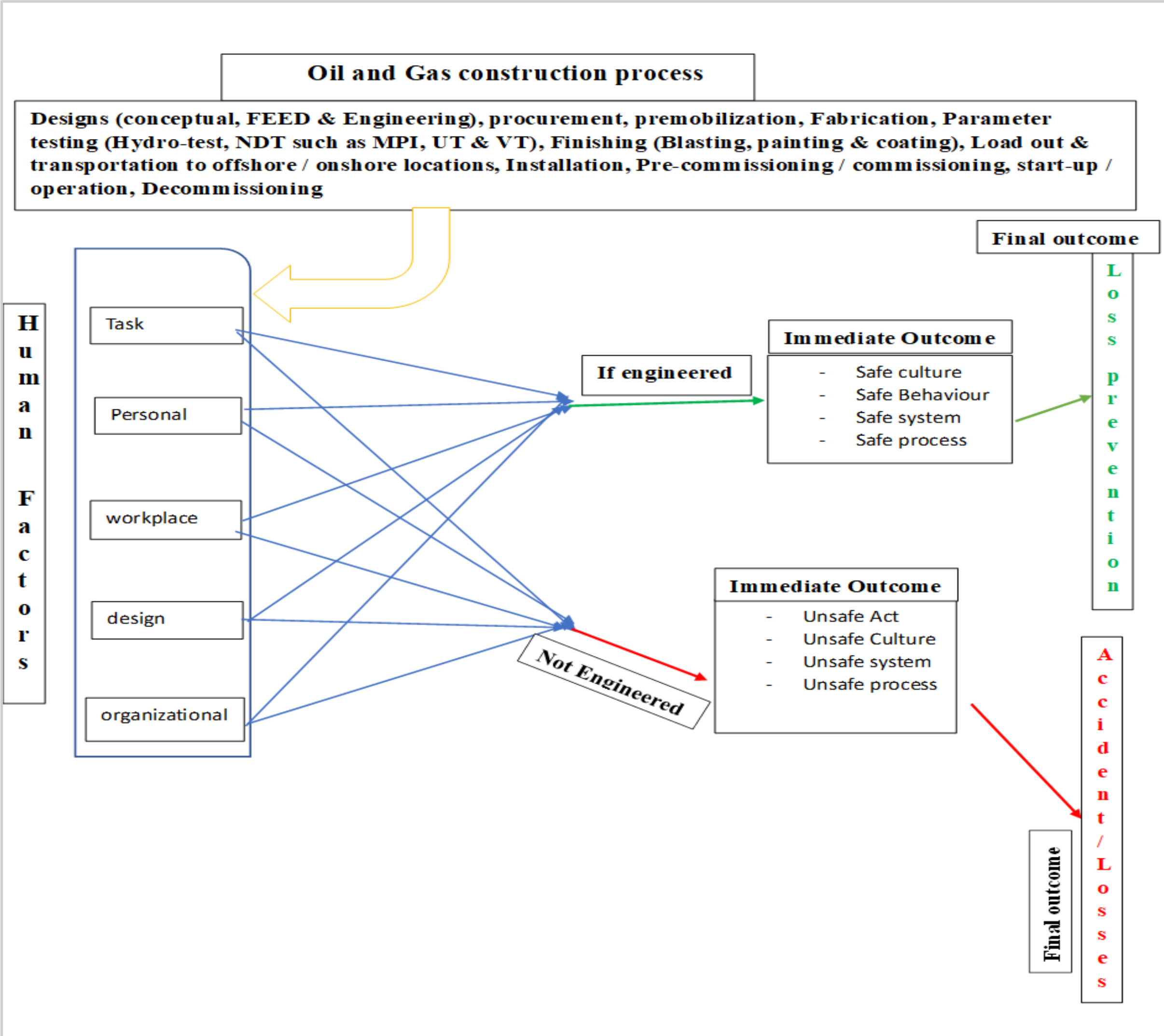

Figure 2. Conceptual models for human factor engineering (HFE) processes in the Nigerian oil and gas construction industry

In oil and gas construction projects, human-related factors are the primary causes of accidents, but when properly engineered, they can also serve as preventive measures.

In order to produce human element engineering and socio-technical networks that result in loss avoidance, enhanced quality, better productivity, and increased profitability, human factors must be integrated and interacted in a special way (OGP, 2011). This demonstrates that designing workplaces with human-related factors in mind is essential to achieving maximum human components in the construction workstation and achieving set goals, which include completing construction activities without incurring any losses from labour injuries or fatalities, ecological harm, equipment malfunctions, or reputational damage. When building construction projects, socio-technical variables in human factor design must be considered, including the people (individual) factor, institutional factor (work structure), task (work and environment), and system design (equipment) factors. The increased work-related injuries and associated frequency of occurrence in construction projects are attributed to the involvement of numerous workers, modern construction methods, vast and highly demanding machinery, a large quantity of materials and specialized technology, convoluted construction implementation, a myriad of interfaces, and varied disciplinary characteristics of the workforce. These mishaps could be caused by falling from great heights, impacts, toppling, and electrocution; with impacts and falls (from high altitude) occurring the most frequently. The Front-End Engineering Design (FEED), comprehensive engineering design, and conceptual design safety in design systems, risk examination and control systems, personnel sources and training, Permit to Work (PTW) systems, device configuration and servicing system, system design checks and monitoring (inspections, audits), and emergency response systems are all included in the conceptual framework for human factor engineering developed for this study as shown in Figure 3.

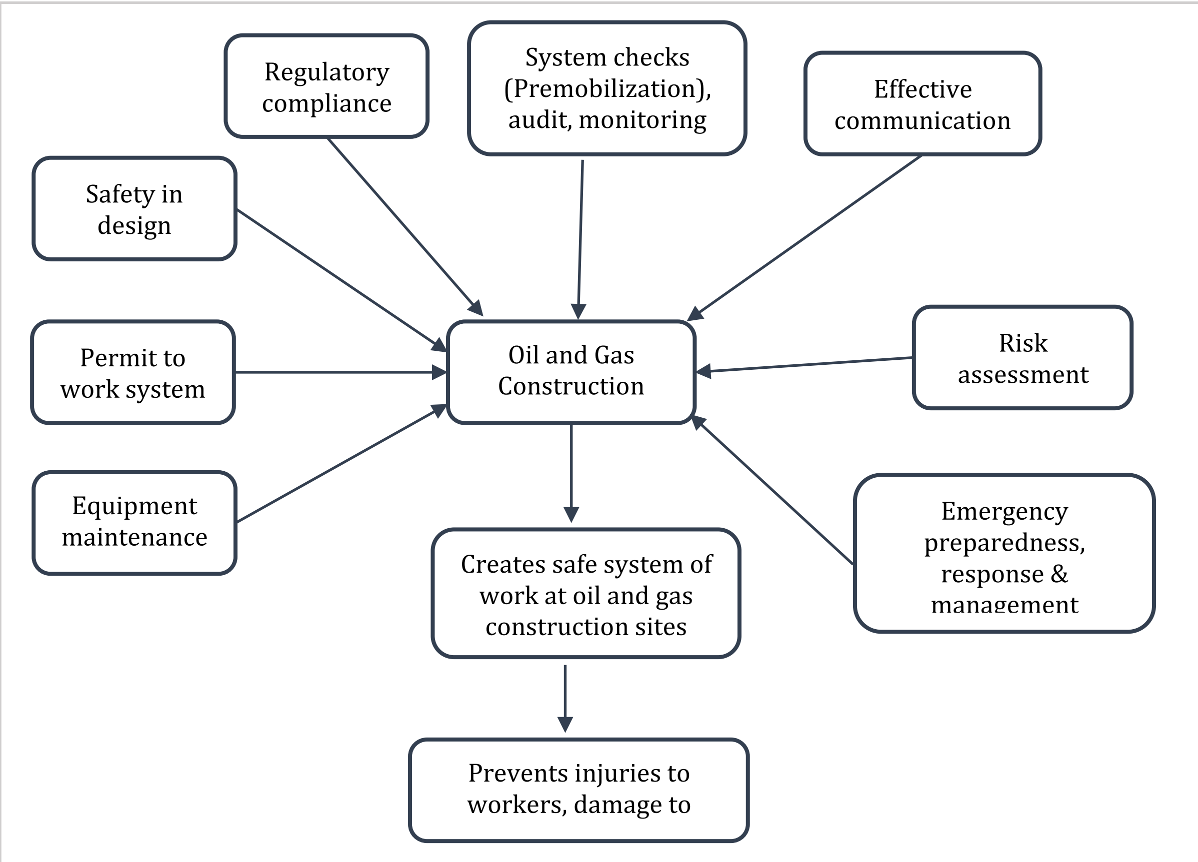

Figure 3. Human Factor Engineering in Nigerian oil and gas construction for incident prevention strategies

Methodology

The research instrument used for the collation of data was a structured questionnaire deployed to oil and gas construction workers in Lagos (latitudes 6° 23” N and 6° 41” N and longitudes 2° 42” E and 3° 42” E), Port Harcourt (4^{o} 45” N and 6^{0} 9” E), and Warri (3^{0} 0” N and 6^{0} 21” E). 350 questionnaires were administered to the sample population, and 295 completed questionnaires were returned and used for the study. The questionnaire contained different sections, including demographics, human factors constituting performance error precursors, including workplace, task, personal, organizational, and design factors. Also, the impact of human factor engineering on workers’ behavior was considered. Likert point scale (Strongly agree =5; Agree = 4; Disagree =3; Strongly disagree = 2; Neutral = 1) was used

The purposive sampling method was used due to the availability of time, nature of the study, accessibility of the oil and gas construction companies, and their activities, since their activities were not common in all cities and towns of Nigeria. This type of sampling technique does not support statistical generalization but supports a deep and context-rich understanding of the research niche. It helped the researchers to select participants with specific knowledge, experience, or characteristics relevant to the research objectives. It allowed to target cases that were especially informative and populations that were overtly relevant to the study. Also, due to limited time for the research, the purposive method was chosen, and it helped focus only on the relevant sample population that aligned with the research objectives.

Data collated from the research instrument (questionnaire) was computer processed using the statistical package for the social sciences (SPSS) version 26, which comes with analysis of moment structure (AMOS) and structural equation modelling (SEM) methods.

Descriptive statistical tools such as frequency count, percentage counts, mean, standard deviation, and median were deployed. Pearson correlation coefficient was used as an inferential test, using significance levels of 0.05 and 0.01.

Sample population estimation was done using Cochran’s formula (Cochran, 1977) for calculating sample size when the population is infinite at a 95% confidence level with ±5% precision as follows:

$$n_0=\frac{z^2pq}{e^2} \qquad (1)$$

Where;

n_o is the sample size; z is the selected critical value of desired confidence level,
p is the estimated proportion and q = 1- p; e is the appropriate degree of accuracy.

Results

During this study, a total of 350 questionnaires were distributed, 25 (7.14%) were not returned, 35(10%) were not completed and correctly filled out, hence only 295(84.29%) questionnaires were used for the analysis, as shown in Table 1.

Table 1: Responses to the questionnaires distributed to oil and gas workers

Survey Parameters	oil and gas construction Workers in Nigeria	
	No. of Questionnaires	Percentage
Total copies of questionnaires distributed	350	100%
Unreturned copies of questionnaires	25	7.14%
Incomplete copies of questionnaires	35	10.00%
Completed and usable questionnaires	295	84.29%

The distribution of the years of working experience is heavily skewed to the right, which indicates that most of the workers have a mean year of working experience of 6.4 years, while the median year of working experience is 4 years. The median value represents the true years of working experience, as shown in Figure 4.

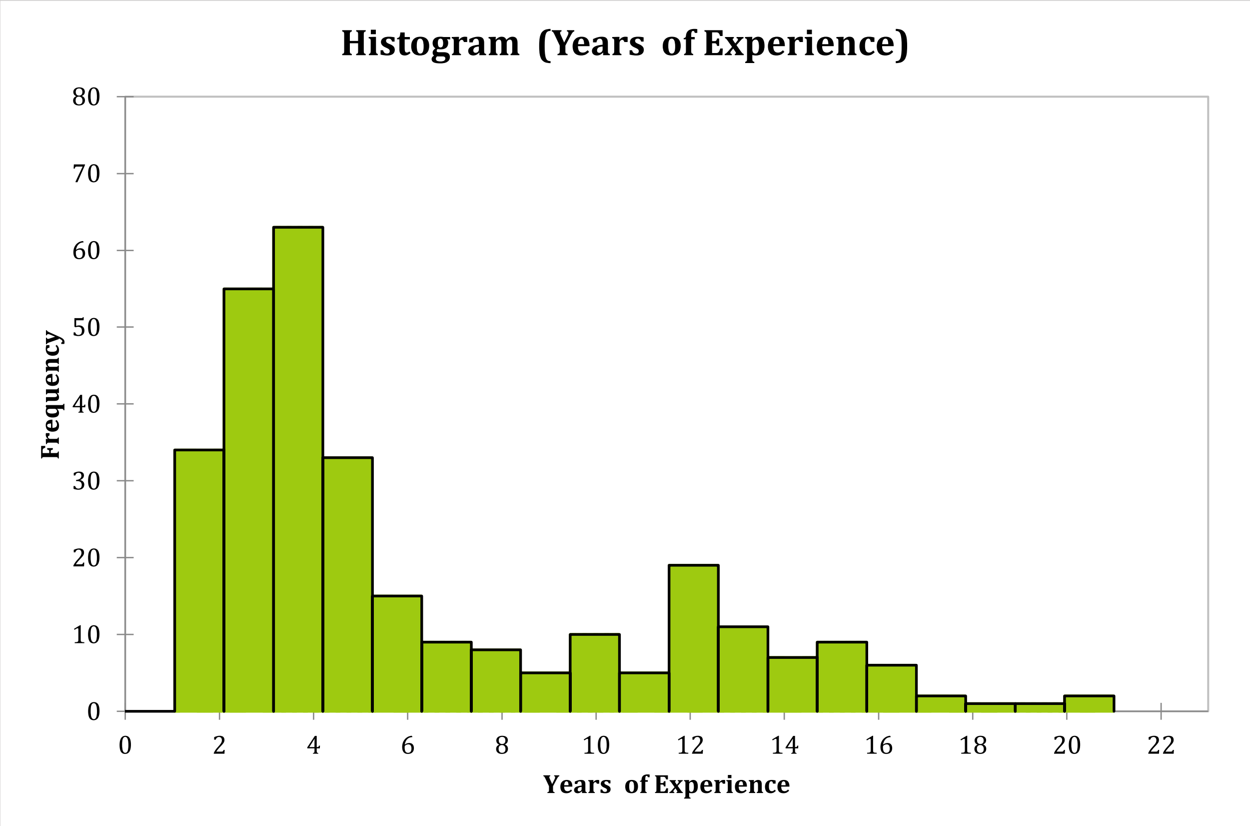

Figure 4. Distribution of years of experience

Descriptive analysis of the study using the Pearson correlation coefficient revealed the human factors that constitute human performance error precursors in the Nigerian oil and gas construction industry, which can be modeled to achieve incident prevention in the management of the oil and gas construction industry.

Pearson correlation coefficient data from the study showed that all the identified human factors are statistically significant to safety outcome (hence incident prevention), indicating that these human factors form the building blocks in determining prevention in the Nigerian oil and gas construction industry.

Descriptive analysis carried out showed that human factors such as workplace, personal, organizational, and design factors constitute human performance error precursors in the Nigerian oil and gas industry. Mean responses from the study instrument showed that human factors such as personal, design, organizational, and workplace factors had a direct correlation with the construction processes and will affect human performance during construction operations in the oil and gas industry in Nigeria.

Table 2: Summary of the human factors and their mean responses from the study population.

s/n	Human Factor	Mean response	Interpretation
1	Workplace	3.78	Responders agree that their poor workplace conditions, such as extreme hot weather, poor ergonomic workstations, and awkward positions of construction workers, were unsafe, and affected their safety performance, safety behavior, negatively leading to poor organizational safety culture and an increase in total recordable injury frequency rates
2	Task	2,28	Responders disagreed that tasks were not planned; hence, it was planned prior to execution. This leads to positive safety behavior of workers, improved safety performance and organizational safety culture of the construction companies, leading to incident prevention and minimization of total injury recordable frequency rates.
3	Personal	2.40	Workers disagreed that they were being pressured at construction sites to obtain productivity results or targets. This showed that organizational safety culture is entrenched in the construction sites
4	Organizational	3.92	Responders agreed that management consults them before developing procedures and safe work practices, which showed an improvement in safety culture within these construction companies
5	Design	3.98	Responders agree that only qualified and certified experts are used during the design stage of the oil and gas construction process in Nigeria.

The mean response by respondents to the workplace factor was 3.78 (Table 2), which indicates that most workers agree to a reasonable extent that the workplace factor in their companies was not ideal for good working conditions. Most of the workers agree with the fact that they were exposed to high temperatures, poor lighting, and high noise. They also agreed to the fact that they were exposed to ergonomically unfriendly conditions (such as their workspace being too small). For the task factor, the mean response by the respondent obtained was 2.28, which indicates that most of the workers disagreed on the task factor condition. Most of the respondents believed their task is planned by management, and they do not carry out the task without a job hazard assessment**.**

For the personal factor, the mean response by the respondents was 2.40, which indicates that most of the workers disagreed about the personal factor. Most of the respondents stated that they do not feel pressured or nervous when executing their jobs. For the organizational factor, the mean response by the respondents was 3.92, which indicates that the respondents tend to agree with this factor. Most of the respondents agreed to the fact that management consults workers before developing procedures and safe work practices are deployed for workers' use. The mean response by respondents for the design factor was 3.99, which suggested that most of the respondents agreed to this factor. Most of the respondents agreed to the fact that qualified and certified people are involved in the design process, and safety is considered during the construction design stage. For safety performance improvement, the mean response by respondents was 2.74, which indicates that most of the respondents were not so sure about safety performance improvement because of the human factors engineering.

The mean response for behavioral safety and culture was 4.17 which suggests that most of the respondents agree with this factor. Most of the respondents agreed that improvement in top management compliance with safety rules has contributed to a positive safety culture in their companies. Also, respondents agreed that making safety moments compulsory in all meetings of the organization has increased safety consciousness and improved the safety culture in their organizations.

The structural equation model diagram from the study showed that the human factors, when engineered, were statistically significant to safety performance improvement, as seen in Figure 5, which is the major purpose of the human factor engineering model developed.

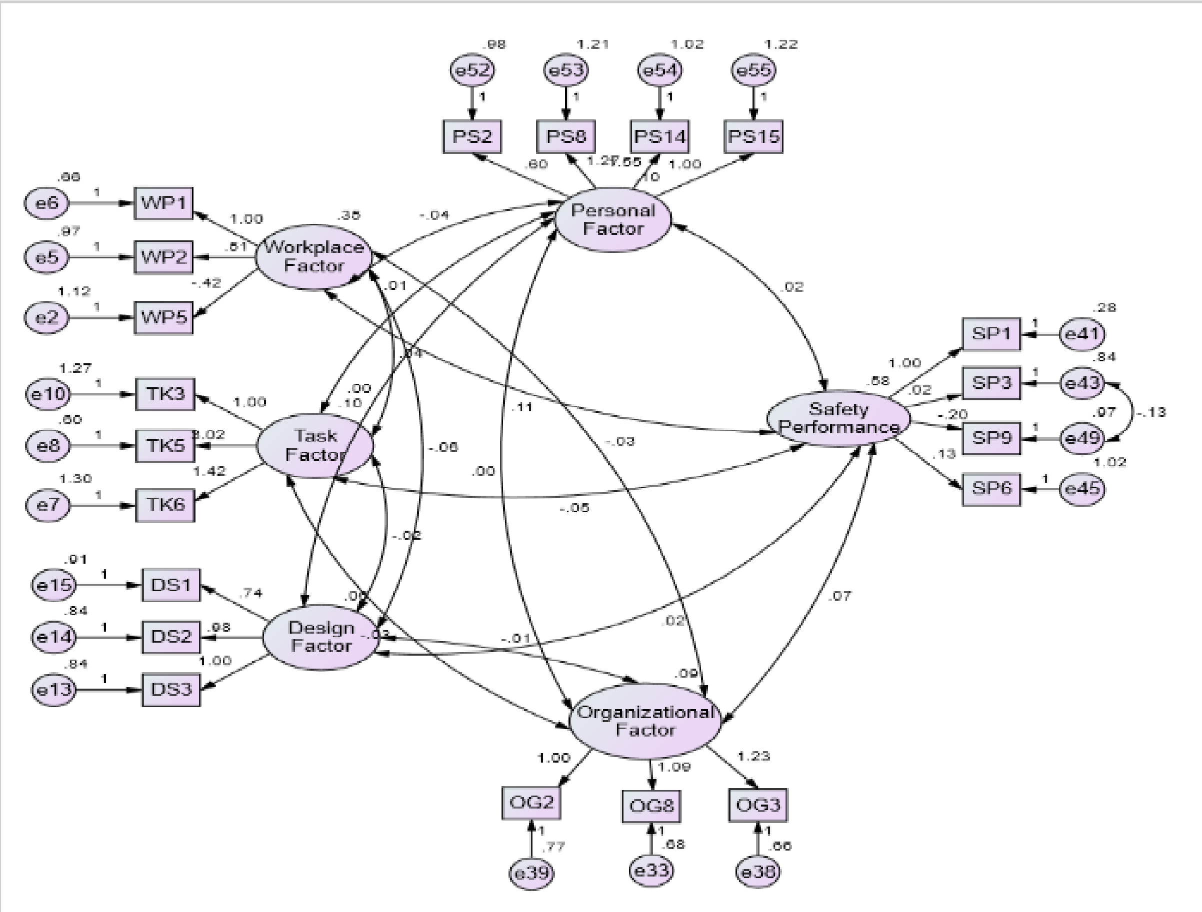

Figure 5. Measurement model for the relationship between human factor engineering and safety performance improvement

A human factor engineering model was developed leveraging the conceptual model for this study and the result of the Pearson correlation coefficient. This model was also developed by adapting Energy Institute (2012), human factor engineering model. Figure 6 shows the human factor engineering model that could be used for safe management of safety in the Nigerian oil and gas construction industry.

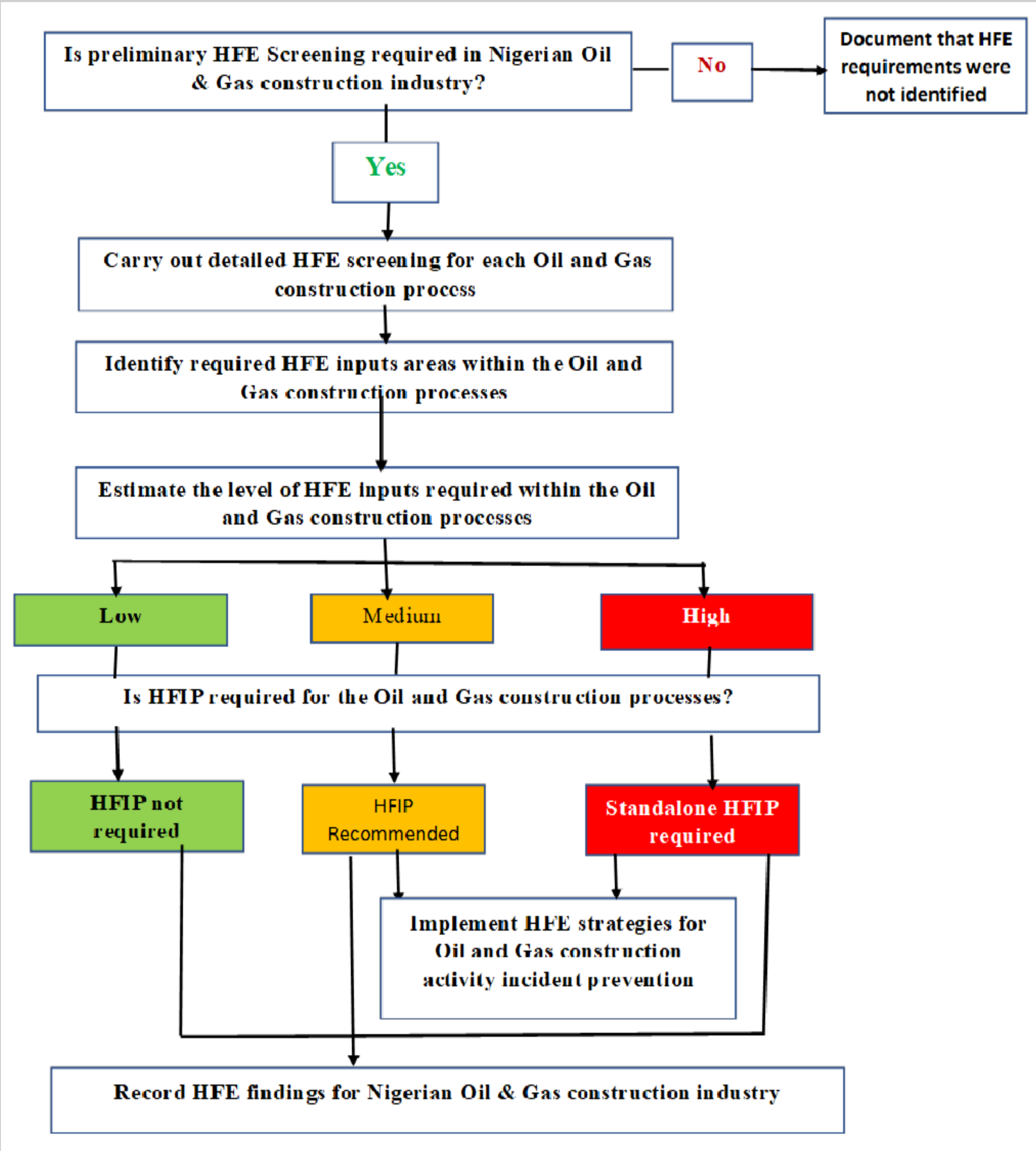

Figure 6. Human factors engineering model for safe management of construction works in Nigerian oil and gas

Screening processes

Preliminary HFE screening process considered questions such as:

i. Will the new construction involve new plant that requires manual operations?

ii. Will the construction introduce human machine interface?

iii. Will the construction involve changes in plant or facility layout?

- Detailed HFE Screening categorized the HFE inputs required in an Oil and Gas construction project site into low, medium and high with defined scalable characterization as shown below:

i. **Low:** minor changes to task; limited or no change in design of equipment from HFE perspective; Requirement likely to be covered by other construction safety plans.

ii. **Medium:** construction involves complex and time-consuming task that requires human reliability; Significant chance to design new equipment from HFE perspective; HFE input is mandatory

iii. **High:** construction involves complex, time-consuming task that rely on **high levels of human reliability**; Significant scope to design new equipment from HFE perspective; Mandatory need for HFE inputs; Requires specific HFE studies; Has implications for performance of safety critical tasks.

Figure 7. Human factor engineering screening process

Human factor engineering screening is a critical part of the safe management of construction works in the Nigerian oil and gas industry, using human factor engineering models as demonstrated in Figure 6 above. This screening leads to the categorization of human factor inputs as low, medium, and high depending on the level of changes experienced in the construction process during screening.

Discussion

During this study, a total of 350 questionnaires were distributed to understand how a human factor engineering model could be developed to support incident prevention in the oil and gas construction industry. 295 responses representing 84.29% used for the research resulted in accurate data collection with interpretable results and minimal errors. This study had a response rate of 84.29%, which indicated that oil and gas construction workers were willing to participate in the research. The Nigerian oil and gas industry is characterized by a young population, as the study indicated that 88.6% respondents were between the ages of 20 and 50 years old. 91.8% are graduates and have postgraduate qualifications, which shows that the industry is populated with workers who can read and write, which makes learning and communication within the construction site easier. 78.6% of the total respondents were married, while 17.6% were single. This showed that most of the respondents could have developed more stability emotionally, which contributes to fewer errors due to conflict in the workplace, leading to incident prevention. The mean year of experience with the responders was 6.4 years. This showed that the responders had robust knowledge of the industry, including safety that could be engineered to obtain the desired goal of incident prevention in the oil and gas construction industry. To achieve this objective, many literatures were reviewed, and descriptive studies were carried out to determine the human factors that constitute human performance error precursors in the Nigerian oil and gas construction industry. The study showed that the following human factors affect oil and gas construction processes in Nigeria. According to the research, the factors that constitute human performance error percussors are task factors, workplace factors, organizational factors, design factors, and personal factors, which agree with the Energy Institute (2012).

These human factors identified have influenced the safety performance in the Oil and gas construction sector in Nigeria. The mean response for workplace factor was 3.78, which indicated that these responders agree that their workplace conditions were unsafe and affected their safety performance, safety behavior negatively, and ultimately led to poor organizational culture and an increase in total recordable injury frequency rates. Some of these unsafe workplace conditions included working in extreme hot weather, a poor ergonomic workstation, and awkward posture of construction workers. Task factor has a response rate of 2.28, which shows that the task was planned before execution. According to the responders, the safety behavior of workers is reinforced, safety performance and organizational culture of the construction companies are improved, leading to incident prevention and minimization of the total injury recordable frequency rate. The mean response rate for personal factor is 2.4, which indicates that workers disagreed that they were being pressured at the construction site to obtain results. This showed that organizational safety culture is entrenched in our construction sites. Organizational factors had a mean responder of 3.92, which indicated that management consults them before developing procedures and safe work practices for workers' use, which showed an improvement in safety culture within these construction companies. The mean response for the design factor was 3.99, which suggested that only qualified and certified experts are used during the design stage of the oil and gas construction process in Nigeria. This contributes to the reinforcement of safety behavior among workers, boosts safety performance, enhances safety culture, and ultimately leads to incident prevention in the Nigerian oil and gas construction industry. Safety behavioral and organizational culture had a mean response of 4.17, which suggested that top management compliance with safety rules contributed positively to safety culture in their companies. They also affirmed that making safety moments compulsory in all meetings of the organization increased safety consciousness, impacted the safety behavior of workers positively, and improved the safety culture in their construction companies, leading to incident prevention in the oil and gas construction industry in Nigeria.

The PCC data from the study showed that all the identified human factors are statistically significant to safety performance, indicating that these human factors form the building blocks in determining the safety performance in Nigerian oil and gas construction sector. These safety performance precursors identified during this research and in alignment with Energy Institute & IOGP (2020) determine the human factor elements that can be modelled to manage safety in the Nigerian oil and gas industry. The measurement model diagram from the study revealed that there is a strong relationship between human factors when engineered and safety performance. This aligns with the principle enunciated by ILO & Graham (2010). This model diagram supported the development of this human factor engineering model for the oil and gas construction in Nigeria

The Nigerian oil and gas industry is characterized by high risk, and the need to develop a safe model that is human-related was very eminent, hence the need for this research. A conceptual study approach of the human factor engineering principles in the oil and gas construction industry was adopted. First, the oil and gas construction processes were determined through literature review and descriptive analysis during this study. Pearson correlation coefficient also showed that human factors had a correlation with safety performance, organizational safety culture and lost time injury frequency.

Thereafter, safe work practices and methodologies were aligned to the construction processes in a bid to ensure that losses are prevented. The safety systems deployed were all human-related systems, which, when engineered (tweaked, monitored) would lead to the prevention of losses in the Nigerian oil and gas construction industry. The Human Factor Engineering model, earlier researched by (OGP, 2011), showed that when human factors are engineered, they can result in accident prevention. This model was adapted to designing a human factor engineering model that is suitable for the safe management of construction activities in the Nigerian oil and gas industry during this study.

Conclusion

The development of a human factors engineering model to support incident prevention in the Nigerian oil and gas construction industry is essential, given the sector's high-risk nature. Human factors identified during this study included task, personal, organizational, workplace, and design factors. These factors can influence workers' safety performance either positively or negatively, depending on how they are engineered.

This study showed that the Nigerian oil and gas construction industry is characterized by high safety risk, poor workers 'safety behaviors, poor organizational safety culture, limited safety performance, and a lack of an integrated construction safety management system. The literature review further revealed that poor workstations, poor planning, irregular safety orientation, and poor communication are among the causative factors in the oil and gas construction industry, which are human factor-related. The research outcome showed that human factors that constitute human performance error precursors on oil and gas construction sites are design, workplace, task, organizational, and personal factors. oil and gas construction accidents have been attributed mainly to these multiple human factors, which are interlinked and influence individual workers is, consistent with findings reported in previous studies, that construction accidents arise from a failure in the interaction between different factors associated with the workers, their workplace and the materials and equipment. Prevention strategies work better when the causative factors are known. Oil and gas construction accidents are primarily caused by human-related factors, which have a great influence on individual workers. The findings of data analysis revealed that there is a significant relationship between these human factors and incident prevention. The engineering modelling of these human factors is very important because accidents still occur in the oil and gas construction industry despite the identification and implementation of the human factors at the site, but without paying attention to the adaptability or engineering of these factors to produce the desired safety goal of prevention.

The study revealed that when human factors are modelled using engineering principles, incident prevention becomes inevitable, business continuity and sustainability are achieved, productivity is enhanced, and profitability is increased. A multi-faceted approach is required for the prevention of accidents in the Nigerian oil and gas construction industry. The three frontal parties involved in this accident prevention, which include construction companies, workers, and regulators, need to accept responsibility to achieve this common goal. Incorporation of this model by the oil and gas construction industry in Nigeria during planning of construction projects may serve as an accident preventive mechanism, which would result in business expansion and continuity.

Declaration of Funding Sources

The authors declare that no external funding was received.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

References

Akintoye, A. S., & MacLeod, M. J. (1997). Risk analysis and management in construction. *International Journal of Project Management, 15*(1), 31–38. https://doi.org/10.1016/S0263-7863(96)00035-X

Arinee, M. S. N., Idris, O., & Rahim, I. B. A. (2021). Human factor engineering in oil and gas construction works: A case study to mitigate safety risk. In *Lecture Notes in Civil Engineering* (Vol. 132, pp. 590–601). Springer. https://doi.org/10.1007/978-981-33-6311-3_68

Alison-Madueke, D. (2012). Development in the Nigerian oil and gas industry, Investment Opportunities. World Bank/IMF Meeting, Japan. https://itpo-tokyo.unido.org/files/WORLD_BANK_IMF_MEETING_JAPAN_2012.pdf

Blackmon, R. B., & Gramopadhye, A. K. (1995). Improving construction safety by providing positive feedback on backup alarms. *Journal of Construction Engineering and Management, 121*(2), 166–171. https://doi.org/10.1061/(ASCE)0733-9364(1995)121:2(166)

Choudhry, R. M., Fang, D., & Lingard, H. (2009). Measuring safety climate of a construction company. *Journal of Construction Engineering and Management, 135*(9), 890–899. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000063

Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.

Elsebaei, M. A., Elnawawy, O., Othman, A. A. E., & Badawy, M. (2020). Causes and impacts of site accidents in the Egyptian construction industry. *International Journal of Construction Management, 22*(14), 2690–2700. https://doi.org/10.1080/15623599.2020.1819523

Energy Institute. (2008). *Guidance on investigating and analysing human and organisational factors aspects of incidents and accidents*. London: Energy Institute. https://minerva.jrc.ec.europa.eu/en/shorturl/benchmarking_exercise/guidance_on_investigating_and_analysing_human_factors_energy_institute

Energy Institute. (2012). *Guidance on quantified human reliability analysis (QHRA)*. London: Energy Institute. https://www.hpog.org/assets/documents/QHRA-Guidance.pdf

Energy Institute, & International Association of Oil & Gas Producers (IOGP). (2020). *Report 454: Human factors engineering in projects* (2nd ed.). Energy Institute. https://www.iogp.org/bookstore/wp-content/uploads/sites/2/woocommerce_uploads/2016/10/454.pdf

Fadun, O. S., & Saka, T. S. (2018). Risk management in the construction industry: Analysis of critical success factors (CSFS) of construction projects in Nigeria. *International Journal of Development and Management Review, 13*(1). https://www.ajol.info/index.php/ijdmr/article/view/172268

Giger, J., & Gaspar, R. (2019). A look into future risks: A psychosocial theoretical framework for investigating the intention to practice body hacking. *Human Behaviour and Emerging Technologies, 1*(4), 306–316. https://doi.org/10.1002/hbe2.176

Hammer, W. (1993). *Product safety management and engineering* (2nd ed.). American Society for Safety Engineers.

Health and Safety Executive (HSE). (2011). *Buncefield: Why did it happen?*. Control of major accident hazards. https://webarchive.nationalarchives.gov.uk/ukgwa/20220701173308mp_/https://www.hse.gov.uk/comah/buncefield/buncefield-report.pdf

Health and Safety Executive (HSE). (2020). *Construction statistics in Great Britain, 2020*. Health and Safety Executive. https://www.mindmapswellbeing.com/_webedit/uploaded-files/All%20Files/2025/Statistics/construction_Health%20and%20Safety%20Executive%20Report%20and%20Mental%20Health.pdf?utm_source=copilot.com

Hess, D., & Winner, L. (2007). Enhancing justice and sustainability at the local level: Affordable policies for urban governments. *The International Journal of Justice and Sustainability,* 12(4), 379–395. https://doi.org/10.1080/13549830701412489

Hulme, A., Stanton, N. A., Walker, G. H., Waterson, P., & Salmon, P. M. (2019). Accident analysis in practice: A review of Human Factors Analysis and Classification System (HFACS) applications in peer-reviewed literature. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 63*(1), 1849–1853. https://doi.org/10.1177/1071181319631086

International Labour Organization (ILO), & Graham, L. (2010). *Working conditions of contract workers in the oil and gas industries* (Working Paper No. 276). International Labour Office. https://www.ilo.org/publications/working-conditions-contract-workers-oil-and-gas-industries

International Association of Oil & Gas Producers (OGP). (2011). *Human factors engineering in projects (Report No. 454)* (1st ed). https://humanfactors101.com/wp-content/uploads/2016/02/human-factors-engineering-in-projects.pdf

International Organization for Standardization (ISO). (2010). *Ergonomics of human–system interaction — Part 210: Human-centred design for interactive systems (ISO 9241-210:2010(E))*. https://richardcornish.s3.amazonaws.com/static/pdfs/iso-9241-210.pdf

Kashwani, G., & Nielsen, Y. (2017). Evaluation of safety engineering system in oil and gas construction projects in UAE. *International Journal of GEOMATE, 12*(29), 178–185. https://geomatejournal.com/geomate/article/view/886

Keulartz, J., & van den Belt, H. (2016). DIY-Bio: Economic, epistemological and ethical implications and ambivalences. *Life Sciences, Society and Policy, 12*(7). https://doi.org/10.1186/s40504-016-0039-1

Lehto, M. R, & Landry, S. J. (2012). *Introduction to human factors and ergonomics for engineers* (2nd ed.). CRC Press. https://doi.org/10.1201/b13249

Leva, M. C., Naghdali, F., & Alunni, C. (2015). Human factors engineering in system design: A roadmap for improvement. *Procedia CIRP, 38*, 94–99. https://doi.org/10.1016/j.procir.2015.08.091

Lingard, H., & Rawlinson, S. (2004). *Occupational health and safety in construction project management*. Routledge. https://doi.org/10.4324/9780203507919

Matias, J. M., Martin, J. E., Rivas. T., Taboada. J., & Arguelles. A. (2009). A Bayesian network analysis of workplace accidents caused by falls from a height. *Safety Science, 47*(2), 206–214. https://doi.org/10.1016/j.ssci.2008.03.004

Muyiwa, O. A. & Sadeghi, K. (2007). Construction planning of an offshore petroleum platform. *GAU Journal of Social & Applied Sciences, 2*(4), 82–85. https://www.slideshare.net/slideshow/jsas-002-0408muyiwa/27781885

Okoye, P. U., Mbakwe, C. C., & Igbo, E. N. (2018). Modeling the construction sector and oil prices toward the growth of the Nigerian economy: An econometric approach. *Economies, 6*(1), 16. https://doi.org/10.3390/economies6010016

Oladinrin, O., Ogunsemi, O. K., & Aje, I. O. (2012). Role of construction sector in economic growth: Empirical evidence from Nigeria. *FUTY Journal of the Environment, 7*(1), 50–60. https://doi.org/10.4314/fje.v7i1.4

Reason, J. (2000). Human error: Models and management. *BMJ, 320*(7237), 768–770. https://doi.org/10.1136/bmj.320.7237.768

Rail Industry Safety and Standards Board (RISSB). (2018). *Railway operations – Management of change* (AS 7472:2018). https://www.ariso.org.au/wp-content/uploads/2019/03/181129_011608_AS-7472_Management-of-Change_final.pdf

Robb, M., & Miller, G. (2012). Human factors engineering in oil and gas: A review of industry guidance. *Work, 41*(Suppl. 1), 752–762. https://doi.org/10.3233/WOR-2012-0236-752

Rosmariani, A., Suraji, A., & Latief, Y. (2019). Study of the causal factors of construction projects' vulnerability to accidents. *International Journal of Innovative Technology and Exploring Engineering, 8*(6), 711–716. https://scholar.ui.ac.id/en/publications/study-of-the-causal-factors-of-construction-projects-vulnerabilit/

Sandberg, J., & Pinnington, A. H. (2009). Professional competence as ways of being: Essential ontological perspective. *Journal of Management Studies, 46*(7), 1138–1170. https://doi.org/10.1111/j.1467-6486.2009.00845.x

Tam, C. M., Zeng, S. X., & Deng, Z. M. (2004). Identifying elements of poor construction safety management in China. *Safety Science, 42*(7), 569–586. https://doi.org/10.1016/j.ssci.2003.09.001

Thomas, D. O., Nwaichi, E. O., & Patricks, C. (2023). Mitigating recordable incidents in Nigeria's oil and gas construction industry: A human factor engineering (HFE) approach. *Journal of Scientific Research and Reports, 29*(11), 1–13. https://doi.org/10.9734/JSRR/2023/v29i111803

Thomas, D. O., Nwaichi, E. O., & Patricks, C. (2025). Enhancing workplace safety through innovation and human factors engineering: A collaborative approach among academia, industry, and government. In *Triple Helix Nigeria SciBiz Annual Conference 2024*. Springer. https://doi.org/10.1007/978-3-031-81619-2_8

Thomas, J., Baker, C. C., Malone, T. B., Malone, J. T., Hard, C. L., Rezende, I. C. L., Caruana, S., & Witten, M. (2002). Application of human factors in reducing human error in existing offshore facilities. *United States Department of Transportation Publications & Papers, 34*. https://digitalcommons.unl.edu/usdot/34

Wiegmann, D. A., & Shappell, S. A. (2001). A human error analysis of commercial aviation accidents using the Human Factors Analysis and Classification System (HFACS). *Embry-Riddle Aeronautical University Commons*. https://commons.erau.edu/publication/1216

Wolbring, G. (2009). What next for the human species? Human performance enhancement, ableism and pluralism. *Development Dialogue, 54*(Aug), 141–163

Zou, P. X. W., Redman, S., & Wildon, S. (2008). Case studies on risk and opportunity at design stage of building projects in Australia: Focus on safety. *Architectural Engineering and Design Management, 4*(3). https://doi.org/10.3763/aedm.2008.0082