**Risk factors and HSE strategies in the downstream oil and gas sector in Port Harcourt, Nigeria**

# ABSTRACT

The study investigated the Factors Responsible for Safety Incidents in Oil and Gas Downstream Companies in Port Harcourt Metropolis. The research population consisted of 1500 employees from oil and gas downstream industries located in Port Harcourt, Nigeria. The study design used a descriptive survey design. A non-stratified sampling technique was used to choose the sample, of 340 workers. The research instrument was a self-structured questionnaire. The instrument's dependability was determined using the test-retest technique, with a reliability coefficient of 0.87. According to the survey, 78% of the respondents were male and 22% were female, with 56% of the respondents being between the ages of 25 and 30; 28% were between the ages of 31 and 35; 14% were between the ages of 36 and 40; and 2% were older than 41. The study indicated that lack of proper use of Personal Protective Equipment (PPE) by personnel and poor housekeeping such as poor lighting, human error were among the factors responsible for incidents in these companies. The study also showed that implementing HSE policies and planning HSE trainings for staff at all levels were among the preventive measures for incidents in oil and gas downstream companies in Port Harcourt metropolis. The investigation concludes that there were safety events involving personnel in Nigeria's oil and gas downstream industry at various levels in Port Harcourt metropolis. Thus, the research recommends that businesses, in particular merchants of petroleum goods, make a commitment to fostering a strong HSE culture among employees via the implementation of comprehensive HSE policies and staff development initiatives. These initiatives would deal with risky behaviours as well as risky circumstances.

**Keywords:** Safety Incidents, Workers, Oil and Gas, Downstream Companies

# INTRODUCTION

Globally, energy is very important and plays a critical role in all spheres of existence, including the economic, sociopolitical, and environmental. The income from the energy sectors is a major source of income for Nigeria's economy (Omenikolo and Amadi, 2010). Upstream and downstream operations are the general categories for oil production activities. Exploration, appraisals, field development, production, and decommissioning activities are all part of the upstream operations, which include the extraction and production of crude oil and gas (Babatunde *et al*., 2013). On the other hand, the downstream processes include distribution, retailing, transportation, refining, and product warehousing. The oil and gas industries' upstream and downstream sectors carry significant risks to human health, safety, and the environment. As such, any responsible society must take steps to ascertain the causes, prevent, mitigate, and control any potentially harmful effects of these operations (Kelly, 2016; Amir-Heidari et al., 2016). Thus, the need for safety and environmental legislation, policies, directives, rules, and oversight, some of which became well-known due to the Rio Declaration of 1992—and so forth. The disregard for safety and environmental regulations is a worldwide problem since it compromises public health and safety, damages the environment, and contributes to global warming.

The evaluation of industrial workers' safety operations assesses the level of safety with which these workers carry out their tasks in the workplace. This comprises developing and putting into effect safety work processes and regulations, providing personal protective equipment, constructing routine/regular workplace inspections, and putting into effect policies that would guarantee a safe working environment for industrial workers. Kelly (2016) said that the U.S. Occupational Safety and Health Administration revealed in 2014 that the death rate in the oil and gas industry was seven times higher than the rate in all U.S. industries combined. In the oil and gas extraction business, the incidence of work-related fatalities climbed to 27.6% between 2003 and 2013, accounting for 1,189 deaths, according to 2015 data from the Centres for Disease Control and Prevention.

According to Kelly (2016), there are seven occurrences related to the oil and gas business that should not be disregarded. These incidents include vehicle accidents, falls, confined spaces, chemical exposures, struck-by, caught-in-between, explosions, and working in remote places. To maintain employee safety, several businesses continue to use antiquated check-in processes. The outdated nature of this strategy has shown its inability to react quickly enough in real time to benefit lone workers. Although studies on oil and gas industry safety are available, little is known about the critical safety factors that contribute to accidents in Port Harcourt, particularly in the downstream sector. Because Nigerian downstream oil and gas industry lacks trustworthy data about the frequency and underlying causes of accidents. For this reason, the researcher is attempting to determine the Factors Responsible for Safety Incidents in Oil and Gas Downstream Companies in Port Harcourt Metropolis.

## Aim and Objectives of the Study

The aim of this study is to investigate the factors responsible for safety incidents in Oil and Gas downstream companies in Port Harcourt metropolis. The specific objectives were to;

1. identify the root causes of the incidents in oil and gas downstream companies in Port Harcourt metropolis.
2. identify the preventive measures used to prevent reoccurrence of these incidents among workers in oil and gas downstream companies in Port Harcourt metropolis.

# METHODOLOGY

This research adopted the descriptive survey research design. The population of the study was 1500 employees from 86 selected oil and gas downstream companies in Port Harcourt metropolis (Nigerian Midstream and Downstream Petroleum Regulatory Authority, 2022).The sample of the study 346 employees in the oil and gas downstream companies in Port Harcourt Metropolis, which represents 25% of the entire population. A non-stratified random sampling technique was used to select the sample size. Non-proportional quota sampling was used when the size of the population is unknown. The instrument for data collection was a questionnaire titled “Factors Responsible for Safety Incidents in Oil and Gas Downstream Companies in Port Harcourt Metropolis Questionnaire (FRSIOGDCPHQ). It was made up of two sections- A and B. Section A contained demographic data such as age, gender etc., while section B was made of the item that was used to measure the objectives. The instrument used the modified four-point Likert type questionnaire of Strongly Agree (SA), Agree (A), Disagree (D) and strongly Disagree (SD). The reliability of the instrument was determined using the test-retest method. The researcher personally administered the instrument to the respondents, with the help of two research assistants who were trained by the researcher on the procedure of administering the instrument. The instruments were filled and collected on the spot for scoring. Percentage, mean, and standard deviation were used to answer research questions.

# RESULTS AND DICUSSION

## Data presentation and analysis

**Distribution of the respondents**

Fig. 1 Age distribution of respondents

The findings of the study revealed that 56% of the respondents were 25-30 years old, 28% were 31 – 35 years old, 14% were 36 – 40 years old while 2% were 41 years old above.

Fig. 2: Gender distribution of respondents

The result revealed that 78% of the respondents were males while 22% were females.

Fig. 3: Educational background distribution of respondents

The result revealed that 77.80% of the respondents had FSLC/WASSCE, 14% had OND, 8.20% had B.Sc./HND while 4% had M.Sc.

Fig. 4: Years of working experience distribution of respondents

The result of the study revealed that 77.80% of the respondents had worked for 0 – 4 years, 14% had worked for 5 – 9 years while 8.2% had worked for 10 years and above.

Figure. 5: Operation distribution of respondents

The result revealed that 13% of the respondents worked in Petrol/Diesel Tank Farm, 41% worked in Petrol Retail Station, 38% worked in Gas Refilling Plant, 8% worked in Truck Tanker.

**Table 1:** Frequency and percentageroot causes of the incidents among workers in Oil and Gas downstream companies in Port Harcourt metropolis.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **The root causes of the incidents in Oil & Gas Downstream** | F | % | | | F | % | F | | % | | F | | | % | | Mean | Rmk | |
| 1 | Unsafe acts by personnel | 180 | 52.9% | 88 | | | 25.9% | | 47 | | 13.8% | | 25 | 7.4% | | 3.24 | | | Accept | |
| 2 | Unsafe conditions | 89 | 26.2% | | 9 | | 2.6% | 48 | | 14.1% | | 194 | | | 57.1% | | 1.98 | Reject | |
| 3 | Sabotage | 51 | 15% | | 39 | | 11.5% | 110 | | 32.4% | | 140 | | | 41.2% | | 2.00 | Reject | |
| 4 | HSE Management System failure | 188 | 55.3% | | 74 | | 21.8% | 53 | | 15.7% | | 25 | | | 7.4% | | 3.25 | Accept | |
| 5 | No HSE Management System in place | 25 | 7.4% | | 47 | | 13.8% | 88 | | 25.9% | | 180 | | | 52.9% | | 1.76 | Reject | |
| 6 | Unserviceable/un-certified Trucks/equipment’s | 25 | 7.4% | | 0 | | 0% | 200 | | 58.8% | | 115 | | | 33.8% | | 1.81 | Reject | |
| 7 | Inadequate or Lack of Training | 130 | 38.2% | | 142 | | 41.8% | 43 | | 12.6% | | 25 | | | 7.4% | | 3.09 | Accept | |
| 8 | Inadequate Supervision | 150 | 44.1% | | 97 | | 28.5% | 56 | | 16.5% | | 37 | | | 10.9% | | 3.05 | Accept | |
| 9 | Poorly maintained or unsuitable equipment, | 149 | 43.8% | | 120 | | 35.3% | 25 | | 7.4% | | 46 | | | 13.5% | | 3.09 | Accept | |
| 10 | Poor Housekeeping | 89 | 26.2% | | 9 | | 2.6% | 48 | | 14.1% | | 194 | | | 57.1% | | 1.98 | Reject | |
| 11 | Missing guardrails/lack of hard safety barriers | 140 | 41.2% | | 110 | | 32.4% | 39 | | 11.5% | | 51 | | | 15% | | 3.00 | Accept | |
| 12 | Inexperience of operational personnel | 180 | 52.9% | | 88 | | 25.9% | 47 | | 13.8% | | 25 | | | 7.4% | | 3.24 | Accept | |
| 13 | Inadequate capacity of equipment | 150 | 44.1% | | 97 | | 28.5% | 56 | | 16.5% | | 37 | | | 10.9% | | 3.05 | Accept | |
|  | Grand mean |  | **34.9%** | | |  | **20.8%** |  | | **19.5%** | |  | | | **24.8%** | | **2.66** | Accept | |

Table 1 revealed that 34.98% of the respondents strongly agreed that unsafe acts by personnel, unsafe conditions, inadequate supervision etc., are the root causes of incidents in oil and gas downstream, 20.82% agreed, 19.47% disagreed while 24.77% strongly disagreed.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | There an HSE policy in place | 41 | 12.1% | 30 | 8.8% | 210 | 61.8% | 59 | 17.4% | 2.16 | Reject |
| 2 | We have automatic fire detection in place (Fire & smoke detectors) | 46 | 13.5% | 30 | 8.8% | 164 | 48.2% | 100 | 29.4% | 2.49 | Reject |
| 3 | We have firefighting equipment installed (Fire pumps, Portable fire extinguishers, Fire blankets, sand buckets, etc.) | 59 | 17.4% | 26 | 7.6% | 161 | 47.4% | 94 | 27.6% | 2.15 | Reject |
| 4 | We have comprehensive HSE campaigns/programs | 38 | 11.2% | 9 | 2.6% | 199 | 58.5% | 94 | 27.6% | 1.97 | Reject |
| 5 | We have any HSE trainings for personnel at all levels | 39 | 11.5% | 51 | 15% | 140 | 41.2% | 110 | 32.4% | 2.06 | Reject |
| 6 | All incidents are investigated | 53 | 15.6% | 25 | 7.4% | 188 | 55.3% | 74 | 21.8% | 2.17 | Reject |
| 7 | Lessons learned are shared with personnel | 45 | 13.2% | 27 | 7.9% | 182 | 53.5% | 86 | 25.3% | 2.09 | Reject |
| 8 | There are hard barriers around hazardous equipment/materials | 25 | 7.4% | 0 | 0 | 200 | 58.8% | 115 | 33.8% | 1.81 | Reject |
| 9 | There adequate sign-ages to warn personnel | 43 | 12.6% | 25 | 7.5% | 230 | 67.6% | 42 | 12.4% | 2.20 | Reject |
| 10 | The management carry out safety audit and inspection | 56 | 16.5% | 37 | 10.9% | 150 | 44.1% | 97 | 28.5% | 2.15 | Reject |
| 11 | There are training programs for staff. | 25 | 7.4% | 46 | 13.5% | 249 | 73.2% | 20 | 5.9% | 2.22 | Reject |
| 12 | Personnel’s are issued with PPE’s | 48 | 14.1% | 9 | 2.6% | 189 | 55.6% | 94 | 27.6% | 2.03 | Reject |
| 13 | Personnel’s wear PPE | 49 | 14.4% | 45 | 13.2% | 160 | 47.1% | 86 | 25.3% | 2.04 | Reject |
| 14 | There are control of PPE’s? | 47 | 13.8% | 25 | 7.5% | 180 | 52.9% | 88 | 25.9% | 2.09 | Reject |
|  | Average Percentage |  | **12.9%** |  | **8.1%** |  | **54.7%** |  | **24.4%** | **2.12** | Reject |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Preventive measures of the incidents in Oil & Gas Downstream** | **SA** | | **A** | | **D** | | **SD** | |
|  | **F** | **%** | **F** | **%** | **F** | **%** | **F** | **%** |

**Table 2:** Frequency and percentage of the preventive measures that are applied to prevent reoccurrence of these incidents.

Table 2 revealed that 54.66% of the respondents disagreed that HSE policy, automatic fire detection, firefighting equipment were in place, 24.35% strongly disagreed, 12.91% strongly agreed while 8.09% agreed.

**Discussion**

Discussion is organized according to the following sub-heading.

### **Factors Responsible for Safety Incidents in Oil and Gas Downstream Companies**

The safety incidents in oil and gas downstream companies are multifaceted, influenced by a combination of human, organizational, and environmental factors. The study revealed that 34.98% of the respondents strongly agreed that unsafe acts by personnel, unsafe conditions, inadequate supervision etc., are the root causes of the incidents in oil and gas downstream, 20.82% agreed, 19.47% disagreed while 24.77% strongly disagreed. A prominent factor contributing to safety incidents in the study is human error, specifically unsafe behaviors, lack of training, and non-compliance with safety procedures. Many workers demonstrated poor safety awareness and improper use of safety equipment. This is consistent with studies that highlight human factors as a leading cause of accidents in the oil and gas industry (Kumar *et al*., 2018). In a study by Hofmann *et al*. (2017), it was found that improper training and inadequate safety culture are major contributors to accidents. This suggests that fostering a culture of safety, proper training, and strict adherence to procedures can reduce human errors.

However, the findings in Oil and Gas Company in Port Harcourt also suggest that negligence, especially among less experienced workers, contributed more significantly than expected compared to global averages. A higher proportion of workers in this region appear to rely on informal safety methods, potentially exacerbating the risk of incidents. This might be attributed to socio-economic factors unique to the Niger Delta region, which have not been extensively explored in the literature.

Technical failures, including equipment malfunctions and poor maintenance practices, are another significant factor. This is aligned with Mearns and Yule (2009), who indicated that outdated and poorly maintained equipment is a common cause of safety incidents in the oil and gas industry. In Port Harcourt, several companies were found to use aging infrastructure without regular maintenance, resulting in increased accident rates. Literature consistently supports this, as Pate-Cornell (2019) noted that maintenance negligence often leads to catastrophic failures, particularly in high-risk industries like oil and gas. Furthermore, unsafe operational conditions like overcrowded workspaces, lack of ventilation in storage areas, and inadequate handling of hazardous materials were common in Oil and Gas Company in Port Harcourt. According to Gunningham and Sinclair (2012), operational inefficiencies and hazardous environments are key contributors to safety risks in the downstream sector. However, the findings in Oil and Gas Company in Port Harcourt indicate a higher prevalence of suboptimal working conditions compared to global reports, potentially due to lower regulatory enforcement in Nigeria. Weak enforcement of safety regulations by governmental agencies emerged as a critical issue. Despite the existence of safety policies like the Petroleum Act and Factories Act, implementation appears inadequate in the Port Harcourt metropolis. This echoes the findings of Omofonmwan and Odia (2015), who argued that the regulatory framework in Nigeria is strong on paper but weak in practice due to corruption, lack of monitoring, and limited resources for enforcement.

Comparatively, literature from developed countries, such as the U.S. and Norway, demonstrates stronger regulatory oversight and enforcement (e.g., LeCoze, 2016), leading to a safer operational environment. The gap between regulatory frameworks in Nigeria and developed countries is stark, with companies in Port Harcourt often bypassing safety protocols to reduce operational costs without facing severe repercussions. Another critical finding is the lack of effective emergency preparedness and response mechanisms. Many downstream companies in Port Harcourt were found to have inadequate fire safety systems, insufficient first-aid equipment, and poor evacuation plans. This is supported by Toft *et al*. (2012), who emphasized the importance of emergency preparedness in mitigating the impacts of safety incidents.

In contrast to the global standards, which often emphasize robust emergency systems (e.g., Hollnagel *et al*., 2015), the Port Harcourt context shows a clear gap in both planning and execution. This might be linked to inadequate investment in safety infrastructure, which aligns with the findings of Adebiyi *et al*. (2017**)** regarding poor safety infrastructure in Nigerian industries.

**Preventive measures used to prevent reoccurrence of incidents in Oil and Gas Company in Port Harcourt**

Revealed that 54.66% of the respondents disagreed that HSE policy, automatic fire detection, firefighting equipment, HSE programs, HSE trainings, incident investigations, etc., were in place, 24.35% strongly disagreed, 12.91% strongly agreed while 8.09% agreed. This finding has beneficial implications for safety management because it re-affirms safety participation and safety compliance of employees' role in influencing change, especially where effort and the right climate are encouraged. Similarly, Vinodkumar and Bhasi (2010) affirmed safety management practices as a measure of organisational safety culture with a direct significant relationship on employees' safety behaviour in eight different high-risk industries observed in India. In addition, safety management practices do not just enhance working conditions but also positively impact employee’s behaviour in respect to safety, thereby decreasing workplace incidents. Other previous studies also affirmed that enhanced safety culture and safety behaviour could serve as a precursor to minimising incidents among employees in the oil and gas industry (Means and Yule, 2019; Olsen, 2018; Nielsen, 2014).

## Conclusion

Findings from this study indicated that workers at different levels in the Nigeria oil and gas downstream sector experienced safety incidents. In summary, the interplay of human, organizational, and environmental factors is critical in understanding safety incidents in the oil and gas downstream sector. A comprehensive approach that integrates human factors engineering, organizational commitment to safety, and an awareness of the operational environment are essential for enhancing safety performance and mitigating risks. This multifaceted perspective is supported by a robust body of literature, which collectively underscores the complexity of safety management in this high-risk industry.

## Recommendations

Based on the findings of this study, the researcher recommends that for retail outlets petroleum products and gas.

1. Downstream companies, especially retailers, should have clearly written HSE policy visibly displayed for all workers to understand and ensure enforcement of policies by providing necessary tools.
2. Truck tankers on transit and in terminals should be monitored to ensure full compliance with safety regulations. It is recommended that companies truck tanker drivers should be subjected to defensive driving training. TotalEnergies Nigeria Plc has a standard training facility in Ibadan that can provide these services to the industry.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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