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DEVELOPMENT OF AN ELECTRONIC TOOL FOR REPORTING BEHAVIOURAL SAFETY OBSERVATIONS IN SELECTED DOWNSTREAM ENERGY COMPANIES IN NIGER-DELTA

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ABSTRACT

This paper was focused on developing an electronic tool for reporting observed unsafe acts and conditions in downstream oil and gas companies in Niger-Delta. Cross-sectional and analytical research designs were adopted. Three downstream oil and gas companies were sampled using multistage sampling techniques, and sample size of 355 was determined using Fisher's formula. Safety observations were focused on five selected worksite operational concerns such as use of PPE, housekeeping, hot work, equipment handling and general workplace procedures. The risks associated with these procedures were determined using their likelihood and severity. Data for the study was collected using questionnaire. Data analysis was done using descriptive statistics (Weighted mean score (MS), average risk score (ARS) and risk assessment matrix (RAM). The results revealed that the unsafe behaviours associated with use of PPE, hot work, equipment handling and general workplace operation are likely to cause severe injuries and accidents (likelihood and severity mean scores > 3.00) while it is likely that unsafe acts associated with housekeeping will cause injury (likelihood mean score >3.00) and it is also uncertain whether the injuries will be severe (severity mean score =3.00). The results of Risk Assessment Matrices revealed that the risk level of unsafe acts associated with use of PPE (ARS=12.67), hot work operations (ARS = 13.76), housekeeping (ARS=9.24), equipment handling (ARS =10.21) and general workplace operation (ARS =12.85) are high (ARS range of 14≥x≥8 = High Risk Level). Hence, an electronic tool (E-tool) for reporting these behavioural safety observations was

KEYWORDS

Electronic Tool, Reporting, Behavioural Safety Downstream Energy Companies, Niger-Delta

developed using the risk level of the unsafe acts associated with the various worksite operations. It was concluded that a robust E-tool for reporting unsafe acts could be developed using the risk level of the various unsafe acts associated with different worksite operations.

Introduction

It has been estimated that up to 90% of all workplace accidents have human errors as a cause (Energy institute, 2008). Companies from the downstream sector deal with enormous uncertainties which are usually handled manually relying on expert judgement rather than actual data (Brown *et al.*, 2021). Amidst the tumultuous challenges faced by the oil and gas industry, there has been a rapid increase in the implementation of advanced digital technology. This is aimed at achieving safer and more efficient operations while minimizing impact materiality (Brown *et al*., 2021). While digital technologies have been quickly advancing in several industries, the health, safety, and environment (HSE) sector is lagging in adopting these advancements. With the increasing complexity of risks and safety management processes, it has become significantly challenging to effectively utilize data-driven solutions. This is especially true for international organizations that have different levels of digital preparedness throughout their diversified operations worldwide.

The Nigerian oil and gas industry plays a significant role in shaping the economic fortunes of the country through; foreign exchange earnings, and employment opportunities (Solomon, 2021). It is acknowledged as possessing the most well-known petroleum and gas reserves in sub-saharan Africa, producing between 2.4 and 2.7 million barrels per day and ranking world's 12th largest oil producer and a major participant in both the global energy market and the organization of petroleum exporting countries (OPEC). Nigeria is projected to have proved oil reserves of roughly 37 billion barrels (bbl.) and natural gas reserves of 192 trillion cubic feet (tcf), which puts it in seventh place (PRAN, 2017). In the Niger-delta region of Nigeria, there are currently 1,481 oil wells and roughly 150 oil fields. With petroleum making up over half of the GDP, over 85% of government revenue, and over 90% of exports, it has long been a vital component of the national economy (Atsegwasi, 2020). The Nigerian oil and gas industries have a lot of resources and have a big impact both locally and globally (Rui *et al*., 2018). However, the exploration and refining processes of crude oil and gas are accompanied by inherent risks and hazards, which calls for a robust and proactive safety management system (Horbah, 2020). The increased investments in the Nigerian oil and gas sector will therefore increase occurrences of accidents, and environmental issues which consequent potential human health risk. Oil and gas operators are periodically susceptible to the dangers associated with blowouts in their wells, as shown in the 2010 Macondo tragedy (Nwogwugwu *et al.,* 2012). Industries in Nigeria, notably the rapidly expanding oil and gas sector, are confronted with serious challenges due to inadequate OHS procedures for tracking and reporting work-related incidents and injuries as well as insufficient health and safety data. Furthermore, there is a dearth of highly qualified occupational health specialists, a lacklustre safety infrastructure, inadequate funding for safety systems, and insufficient OHS accident and injury monitoring systems. These challenges have prompted regulatory agencies and industry stakeholders to continuously evolve safety practices to mitigate risks and enhance operational excellence (Muazu, 2021). Safety behaviour includes an extensive list of actions, attitudes, and decisions that impacts on the overall safety culture within an organization (Lawati *et al*., 2018). There is variation in safety

behaviours across different organizations in Nigeria including the oil and gas industry, where operational contexts can vary significantly from onshore to offshore environments (Ehiaguina, 2022). Only a few independent investigations on the effects of technology on behavioural safety observation have been done. Understanding the growing importance of technology in maintaining worker safety is especially relevant when considering industries that are essential to the community's economy, like the downstream petroleum sectors in Nigeria. It's worthy to note that the downstream petroleum industries are essential for the distribution, storage, and marketing of petroleum products. Refineries, storage facilities, transportation systems, and retail establishments like gas stations are examples of these industries. Because of this, Niger-delta has a high concentration of infrastructure and activities related to the petroleum industry, which makes it a perfect place to carry out this study. It is also critical to identify specific areas where technology can be used to optimize behavioural safety observation through development of an electronic tool for reporting unsafe acts and conditions. Also, it is crucial to bear in mind, potential challenges and opportunities that may be associated with improvement in BBS practices in reshaping future safety strategies.

Understanding the safety behaviours within the contexts of behavioural safety observation is essential to inform targeted interventions that align with industry-specific challenges. To efficiently facilitate the implementation and enhancement of safety practices in this era of digital transformation, technological integration is a very crucial strategy. Addressing the possible safety concerns connected with the downstream petroleum industry in Nigeria and its significance to the country's economy makes it imperative to investigate how behavioural safety observation tool might enhance behaviour-based safety through E-reporting. Developing an electronic tool for reporting behavioural safety observations has the potential to completely transform the sector in several ways, including tracking repetitive processes and patterns, enhancing risk assessment and decision-making procedures, and improving monitoring systems. The downstream petroleum industry may see a decrease in mishaps and injuries as well as an improvement in overall safety performance with the application of this electronic reporting tool.

Therefore, the aim of the study is to develop electronic tools for reporting behavioural safety observations in selected downstream energy companies in Niger-Delta, and the objectives are to;

1. Determine the likelihood and severity of injuries associated with unsafe acts during various worksite operations in the downstream oil and gas firms operating in Niger Delta
2. Evaluate the risk level of the unsafe acts associated with the various worksite operations in the downstream oil and gas firms operating in Niger Delt
3. Develop an electronic tool for reporting observed unsafe behaviours in the various worksite operations in the downstream oil and gas firms operating in Niger Delta using the risk level using the risk level in objective 2

2. MATERIAL AND METHODS

This study adopted mixed-research design which involve combination of cross-sectional design and analytical design (Morse, 2016). Employing both designs would facilitate a thorough comprehension of opinion of the workers and management of companies in the downstream oil and gas sector in Niger-Delta regarding the unsafe acts and conditions that causes accidents in their workplace and how an E-

reporting tool could be used to report these unsafe acts and conditions based on concept of Behavior-based Safety (BBS) protocols.

2.1 Study Area

Currently, the Niger Delta is mostly recognized as a region that supports extensive oil exploration and exploitation conducted by the representatives of western economic powers. The Niger Delta basin is widely recognized as the primary pillar of the Nigerian economy due to its substantial and abundant oil reserves. The region also possesses substantial and commercially exploitable resources of hydrocarbons and natural gas reserves. Petroleum and its byproducts are the primary drivers of the Nigerian economy, accounting for over 90 percent of exports, over 80 percent of the government's annual revenue, and 70 percent of budgeted expenditure. The Nigerian government receives approximately US$ 20 million per day from its crude oil reserves. Currently, Nigeria possesses more than 21 billion barrels of verified oil reserves. Nigeria is the biggest oil producer in Africa and ranks as the sixth most significant exporter of crude oil globally, with majority of its exports being sent to the United States. (Bovwe et al., 2016).

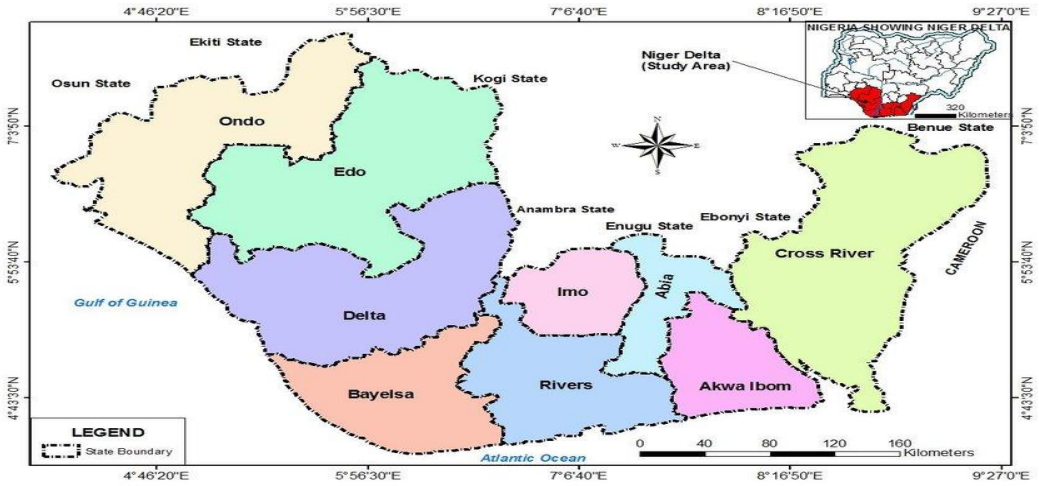


Figure 1: Map of Niger-Delta Showing the study areas

2.2 Population, Sampling technique and sample size determination

The target population of this study was limited to workers in three selected downstream oil and gas enterprises that is located in the Niger Delta region which are actively engaged in storage, processing, distributing or retailing petroleum products. Multi-stage sampling technique and purposive sampling was used to select key respondents from the various companies. The multi-stage or cluster sampling is considered due to the large and dispersed population involved. While purposive sampling was employed to select key respondents from different firms. The respondents were chosen from designated sectors or offices in the downstream companies that have the responsibility of utilizing technology in their operations, alongside other individuals found in the sector

The sample size was determined using Fishers' sample size determination. This sample size formula is used in a study where the population of the study is unknown and the proportion of the population required for the study can be assumed. The formula is expressed as

$$n = \frac{Z^2PQ}{I^2} \quad (1)$$

Where; n = Sample size, Z = Desired confidence level. In this case, it was taken at 95%. Z value at 95% = 1.96, P = Proportion of the population with desired characteristics. Since it is not known, it was taken as 70%. P value = 0.7, Q = Proportion of the population without the desired characteristics; Q = 1-P, I^2 = Degree of Precision, was taken to be 5% (0.05), $n = 322$

To cover for non-response, 10% of 322 was used, resulting to 33 extra respondents. Therefore, the minimum estimated sample size for the three sampled companies was 355 at 5% level of confidence. This is in consonant with the rationale that minimum of 10% population (in hundreds) of the study is appropriate for generalization (Elendu, 2010). Three hundred and fifty-five (355) questionnaire was distributed evenly among the three sampled firms X, Y and Z and also equally allotted among HSE officers, field supervisors and field workers as seen in Table 3.1

Table 3.1 Distribution of the study population and sample size

Sn	Company	HSE Officers	Field supervisors	Field workers	Total
1	X	20	20	79	119
2	Y	20	20	78	118
3	Z	20	20	78	118
	Total	**60**	**60**	**235**	**355**

2.3 Method and instrument of Data Collection

Survey data collection method was adopted by collecting quantitative data using questionnaire. A fundamental premise of survey quantitative research is the philosophical conviction that our reality is reasonably consistent and uniform, enabling us to measure and analyses it, as well as make extensive speculations about it (Maydeu-Olivares & Millsap 2009). The survey quantitative approach is focused on providing a numerical representation of response of study respondents suitable for assessing for methods of reporting behavioural safety observations within the downstream petroleum sector in the Niger-Delta Region in areas

A self-structured questionnaire was used to obtain data for this study. The questionnaire was explained to the respondents before completion of the questionnaires. The questionnaire was titled “Behavioural Safety Observation Reporting Questionnaire for Downstream Oil sectors” and designed to have two sections; Section A was used to obtain information on the likelihood of the unsafe behaviour and condition to cause accident or near-miss in downstream energy companies in Niger-Delta while Section E was used to obtain information on the severity of accidents that could occur due to the unsafe acts and conditions in downstream energy sector in Niger-Delta

The questionnaire is comprised of Conventional 5-point Likert scale comprising of “strongly Agreed (SA) (5), Agreed (A) (4) Undecided (UN) (3), disagreed (D) (2), and strongly disagreed (SD) (1)” This imply that the respondents are not given the room to freely express their opinion on the subjects of the questions rather they are only allowed to present their opinion based on degree or level of their experience and information towards the subject of the questions as was presented to them by the researcher.

2.3.1 Risk Assessment.

This is based on evaluating the risk level of the identified hazards based on their severity and likelihood and then using the risk level to rank the unsafe behavior based on the position in a standard risk assessment matrix. The risk score is based on the product of the Severity of the accident caused by the unsafe behavior and their likelihood of occurrence of the accident, given as

Risk Level (RL) or Risk Score (RC) = Severity (S) × Likelihood (L)

The severity and likelihood of the various unsafe acts associated with the various safety procedures sampled was obtained using questionnaire design and administered to the sampled workers in the downstream oil and gas firms.

2.4 Validity and Reliability of Instrument

The study instrument was validated by experts in Centre for Occupational Health and safety (COHSE), University of Port Harcourt, Rivers State while the reliability was ascertained using Cronbach Alpha test of the pre-test and post-test carried out using 10% of sample size on firms not involved in the survey study but part of the study population. The Cronbach's alpha coefficient of a scale above 0.70 is considered "suitable" for the research as shown Table 2

Table 2 Reliability Coefficient of the questionnaire items

	Operation Unit	Number of questionnaire Items	Cronbach alpha coefficient
1	Likelihood of unsafe behaviour and conditions to cause accident	35	0.73
2	Severity of accident caused by the unsafe behaviour and conditions	35	0.77

2.5 Data Analysis

The study employed descriptive statistical methods (means, percentages, weight average). Descriptive statistics was used to fulfil research objectives which involved quantifying the opinion of the respondents on the Livelihood and severity of unsafe behaviour and conditions in the selected downstream energy companies in Niger-Delta. The analyses were carried out using SPSS version 20. The E-reporting tool was programmed using JavaScript with react js framework (for frontend), python with FastAPI (for backend), Supabase (for storing reports on the database), Cloudinary (for cloud file storage), CSS & tailwind (styling of admin and client portal). The E-reporting tool development was carried out using data from X sampled downstream oil and gas firms. Tested using data from Y company and validated using data from X company. The procedure usd to determine the risk level of various unsafe acts and condition are presented in Figure 2 while the software development involved different stages which are illustrated in the Figure 3

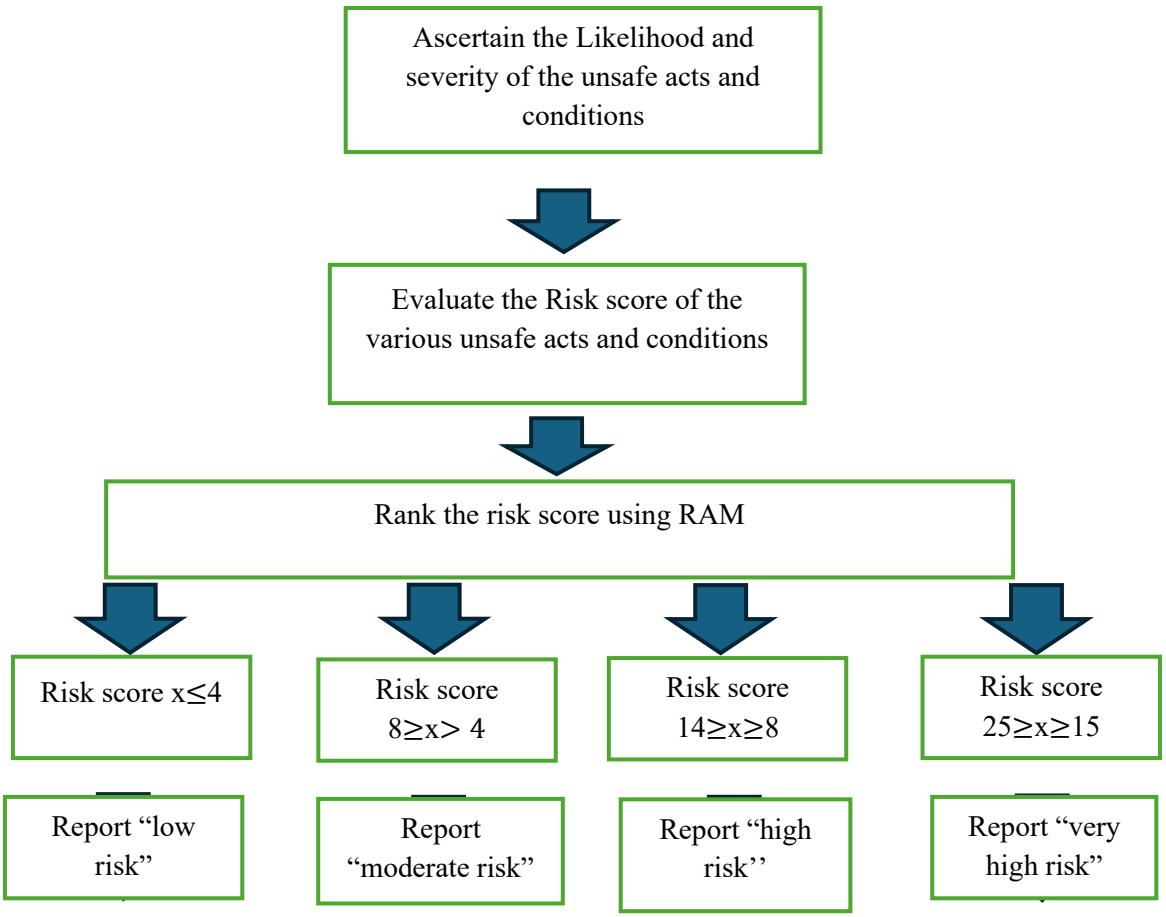


Figure 3.2: Stages in the development of the E-report tool

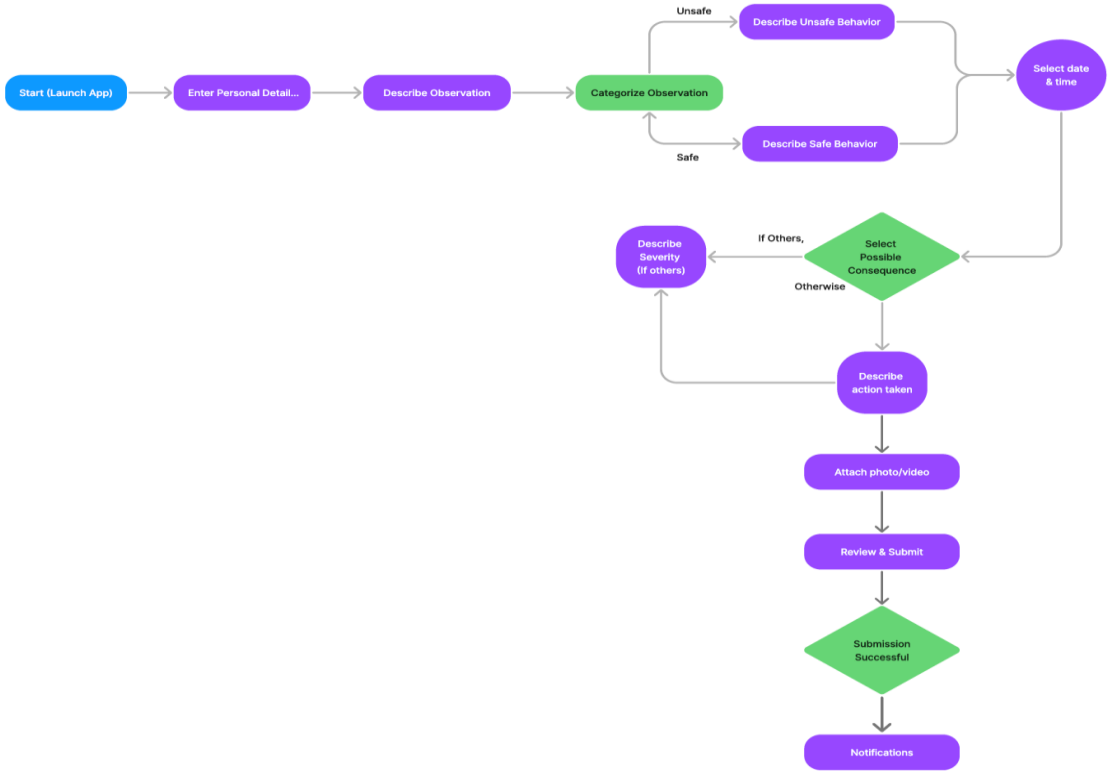


Figure 2: Flow chart/user flow illustrating the stages of the proposed E-report tool

The E-report tool development flow chart/user flow as seen in Figure 3.3 involved the following steps.
STEP ONE; Entry point

Launch app

Tap “get started”

STEP TWO; Personal details

Full name, mobile number, department, supervisor/line manager

Option: report anonymously

STEP THREE; Report observation

Describe what you observed

STEP FOUR; Categorize observation

Unsafe behaviour / unsafe condition / safe behaviour / safe condition

STEP FIVE; Add details (if unsafe)

Describe unsafe behaviour

STEP SIX; Date & time

Select date and time of observation

STEP SEVEN; Possible consequence

Near-miss, injury, fatality/death, damage to asset, others

If "others," describe consequence

STEP EIGHT; Action taken

Describe actions taken to address the situation

STEP NINE; Attach evidence

Upload photo/video (max 5 files, 10MB each)

STEP TEN; Review & submit

Review details and submit

STEP ELEVEN; Confirmation

Submission successful screen

STEP TWELVE; Notifications (post-submission)

Report submitted → under review → approved → closed with action taken

Option to clear notifications

3. RESULTS AND DISCUSSIONS

3.1 Risk level of the unsafe acts and conditions in downstream energy companies in Niger-Delta

The risk levels of the unsafe acts in downstream energy companies in Niger-Delta were evaluated and the results were presented in Table 4 to Table 8. These results covered the risk level of the unsafe acts

associated with the use of PPE, housekeeping, hot work procedures, equipment handling procedures and general workplace safety procedure in the sampled downstream oil and gas companies in Niger-Delta. The evaluation of the risk levels of various unsafe behaviour was evaluated as risk scores which is the product of the likelihood score and severity scores of the items.

On use of PPE, overall risk level revealed that most unsafe act associated with poor use of PPE have High-Risk level. On housekeeping, overall risk level associated with unsafe act linked to housekeeping have High-Risk level. On hot work operations, the overall risk level associated with hot work operation revealed that most unsafe act associated with hot work operation have High-Risk level. Concerning equipment handling, the overall risk level associated with equipment handling revealed that most unsafe act associated with equipment handling operation have High-Risk level. Finally, on the general workplace operations, the overall risk level associated with poor general workplace operations revealed that most unsafe act associated with poor workplace operations have High-Risk level.

The results slightly aligned with the work of Choudhry, (2014) who carried out empirical study to investigate the effectiveness of behaviour-based safety in construction firm using conventional monitoring, intervention and reporting approach. The weekly scores were discussed in the weekly safety meetings and other operational site meetings with emphasis on how to achieve set safety performance targets. The reliability of the safety performance measures taken by the company's observers was monitored. A clear increase in safety performance level was achieved across all categories: personal protective equipment; housekeeping; access to heights; plant and equipment, and scaffolding. The research reveals that scores of safety performance at one project improved from 86% (at the end of 3rd week) to 92.9% during the 9th week. The results of intervention demonstrated large decreases in unsafe behaviours and significant increases in safe behaviours. The results of this case study showed that an approach based on goal setting, feedback, and an effective measure of safety behavior if properly applied by committed management, can improve safety performance significantly in construction site environments. The results proved that the BBS management technique can be applied to any country's culture, showing that it would be a good approach for improving the safety of front-line workers and that it has industry wide application for ongoing construction projects

The result is also slightly in line with the work of Inyeneobong and Boluwatife (2022) who carried out study aimed to develop quantitative model that assesses the level of workers' behavioural safety on a construction site based on behavioural observation. A construction firm in Southwest Nigeria was identified and studied. Data on tasks performed by the workers on the number of unsafe behaviours (N) and the durations in which they lasted (D) was collected. Based on this, the level of safety adherence (LSA), the initiated and sustained number of safety violations (I-NSV and S-NSV) and the probability of unsafe acts occurrence and zero unsafe acts (PUA1 and PUA2) indicators were developed and used in assessing the safety level of the project. An evaluation of different levels of N and D was also undertaken to provide further insight into the requirements for attaining an improved systems safety level. The results obtained indicated that the LSA was 0.35. The I-NSV and S-NSV results were 41 and 118 unsafe acts respectively while the PUA1 and PUA2 values were 1.00 and 0.00 respectively. Evaluation results showed that LSA increases were directly related to S-NSV decreases caused by corresponding decreases in D, while improved project safety levels could be achieved through I-NSV mitigation.

Table 4; Risk levels of the unsafe behaviour associated with poor use of PPE in downstream energy companies in Niger-Delta

S/N	Questionnaire Items	Likelihood Score	Severity Score	Risk Score	Remark
1	Failure to hook the Full Body Harness when working at height	4.05	3.05	12.35	High Risk
2	Using Full Body Harness with single lanyard when working at height	4.13	3.12	12.88	High Risk
3	Failure use Self-Contain Breathing Apparatus (SCBA) when working in confine space Like Inside Fuel Tank.	3.85	4.05	15.60	Very High Risk
4	Failure to use proper gloves when working on hot or sharp tool and material	4.45	3.05	13.57	High Risk
5	Failure to use goggles and/or earplug when performing activities that require them like welding of tanks	4.55	3.15	14.33	Very High risk
6	Wearing worn-out safety boots when working on slippery floors	3.01	2.51	7.56	Moderate Risk
	Overall Risk Score	4.01	3.16	12.67	High Risk

Table 5 Risk levels of the unsafe behaviour associated with housekeeping in downstream energy companies in Niger-Delta

S/N	Questionnaire Items	Likelihood Score	Severity Score	Risk Score	Remark
1	Leaving material or waste at the access path or within their working perimeter	2.18	2.05	4.47	Moderate Risk
2	Failure to put the hazardous and harmful material in the designated positions	3.55	3.65	12.96	High Risk
3	Failure to keep in a save place tools and materials used after working	2.64	2.45	6.47	Moderate Risk
4	Failure to store flammables in accordance to their safety requirements based on proper labelling and proper isolation.	3.95	3.85	15.20	Very High Risk
	Overall Risk Score	3.08	3.00	9.24	High Risk

Table 6; Risk levels of the unsafe behaviour associated with hot work operations in downstream energy companies in Niger-Delta

S/N	Questionnaire Items	Likelihood Score	Severity Score	Risk Score	Remark
1	Failure to wear gloves/apron/mask when performing welding job	3.25	2.75	8.94	High Risk
2	Failure to wear glasses/face-shield when performing cutting and or grinding operations	3.17	3.07	9.73	High Risk
3	Using acetylene tube without flashback arrestor	3.13	3.32	10.39	High Risk
4	Performing hot work operations like welding close to LPG tubes.	4.80	4.90	23.52	Very High Risk
5	Exposing the radiator plug when the machine is still hot.	4.15	4.45	18.47	Very High Risk
6	Failure to remove gas tube and stretch hose in a proper tension when perform cutting with welding machine	2.78	2.88	8.01	High Risk
7	Carrying out wielding or cutting operation on empty fuel tanks without proper washing and cleaning (purging)	4.55	4.75	21.61	Very High Risk
	Overall Risk Score	3.69	3.73	13.76	High Risk

Table 7 Risk levels of the unsafe behaviour associated with equipment handling operations in downstream energy companies in Niger-Delta

S/N	Questionnaire Items	Likelihood Score	Severity Score	Risk Score	Remark
1	Using machinery without protection and/or hand grip	3.01	2.31	6.95	Moderate Risk
2	Failure to give command or signal when moving working equipment along access path.	3.23	3.13	10.11	High Risk
3	Failure to turn off equipment after they finish operations	4.25	3.35	14.24	Very High Risk
4	Failure to carry out or perform pre-inspection on equipment before operation.	2.95	2.73	8.05	High Risk
5	Failure to support their equipment properly before working.	2.85	2.53	7.21	Moderate Risk
6	Using working device beyond their standard usage limit	3.08	3.38	10.41	High Risk
7	Moving device or equipment unsafely and insecurely	3.23	3.43	11.07	High Risk
8	Modifying working device in a manner that make them unsafe to be used	3.25	3.35	10.89	High Risk
9	Failure to apply lock button on the man-lift panel	4.40	3.15	13.86	High Risk
	Overall Risk Score	3.36	3.04	10.21	High Risk

Table 8 Risk levels of the unsafe acts associated with general workplace procedures in downstream energy companies in Niger-Delta

S/N	Questionnaire Items	Likelihood Score	Severity Score	Risk Score	Remark
1	Operating heavy and light equipment in a fatigue condition	3.05	3.15	9.61	High Risk
2	Failure to give required command or signal when moving working equipment along access path.	3.11	3.41	10.61	High Risk
3	Smoking outside of the designated locations and areas	4.58	4.83	22.12	Very High Risk
4	Entering dangerous areas (dark, slippery, holes and unsecure areas) without permission	4.25	4.35	18.49	Very High Risk
5	Trespassing barricade of the lifting area or heavy equipment working area	3.35	3.15	10.55	High Risk
6	Standing or loitering within swing perimeter of machines under operation	3.12	3.10	9.67	High Risk
7	Continuing working operation under rainy condition	4.43	4.53	20.07	Very High Risk
8	Failure to adopt standard lifting procedure when perform lifting operations	3.55	3.45	12.25	High Risk
9	Performing manual lifting without using the correct posture	2.47	2.64	6.52	Moderate Risk
	Overall Risk Score	3.55	3.62	12.85	High Risk

3.2 E-reporting tool development

Figure 4 to Figure 7 clearly shows details of different interactive pages of the electronic tool for reporting behavioral safety observations.

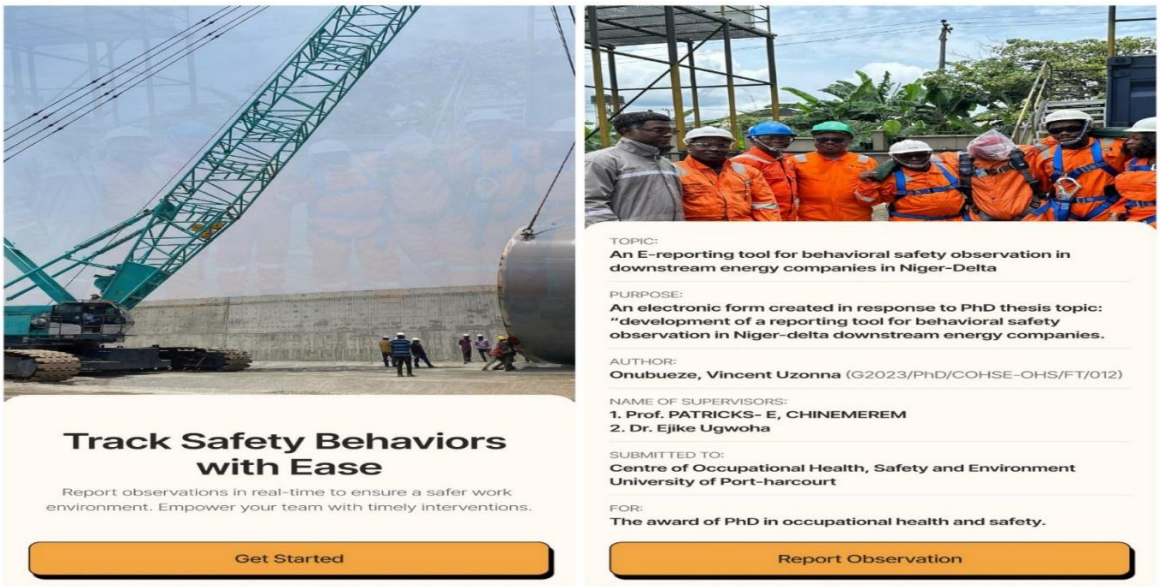


Figure 4. Screenshots of the onboarding and splash screen of the E-report tool

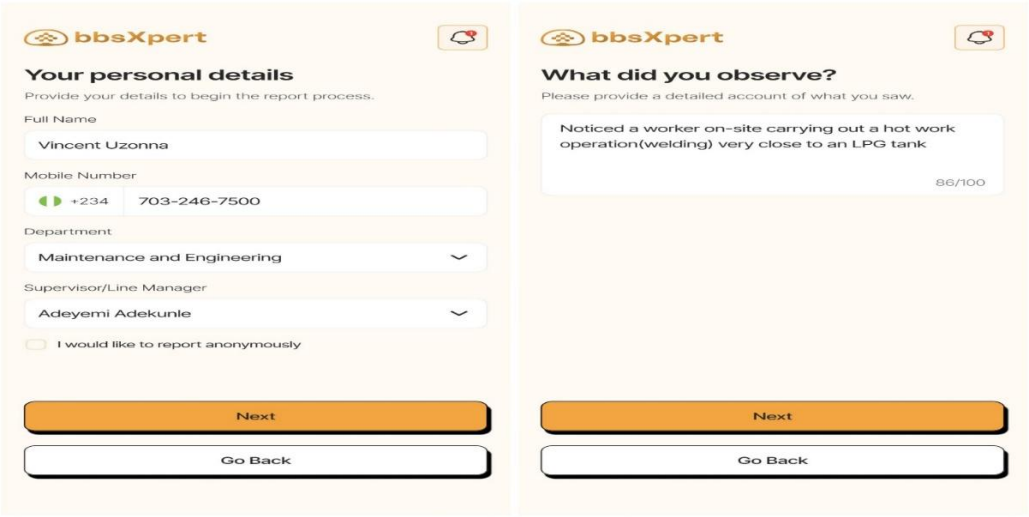


Figure 5 Screenshots of observers sign in page and observation report screen of the E-report tool

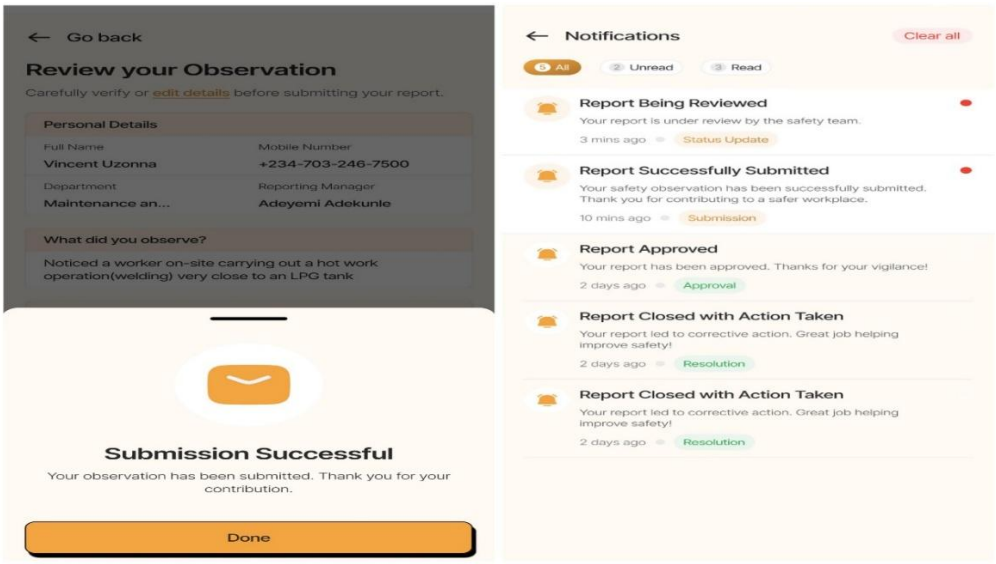


Figure 6 Screenshots of successful observation report submission and notification page of the E-report tool

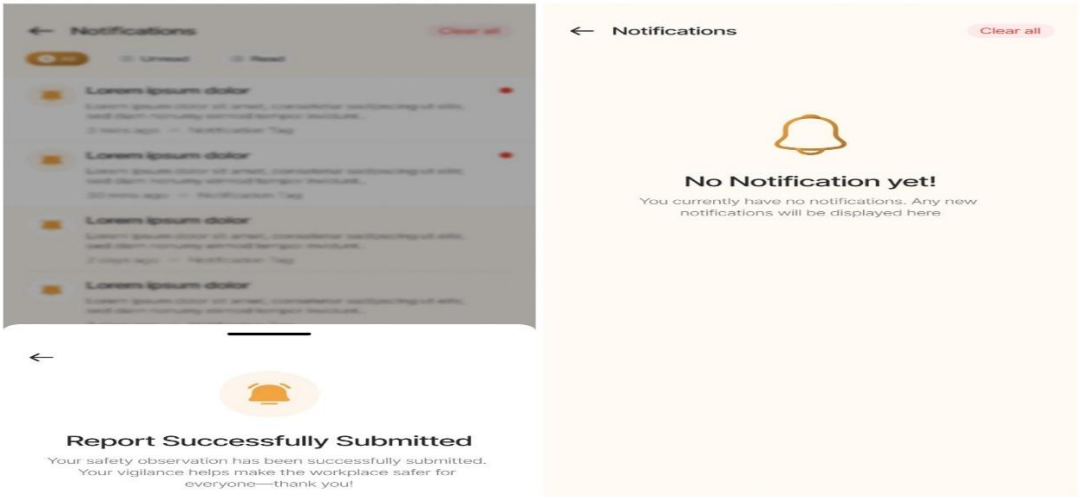


Figure 7 Screenshots of successful observation report confirmation of the E-report tool

4. CONCLUSIONS

This development of electronic tool for reporting behavioural safety observations in selected downstream energy companies in Niger-Delta based on risk level of various procedures in the workplace. Based on the findings of this study, the following conclusions were drawn: one, the unsafe acts on poor use of PPE, housekeeping, hot work operation, equipment handling and general workplace operations all have substantial level of likelihood to cause accident in downstream energy companies in Niger-Delta. Two, most of the unsafe acts and issues on the use of PPE, hot work, equipment handling and general workplace operation can cause severe injuries and accidents while it's unclear whether the accident and injuries caused by unsafe acts relating to housekeeping will be severe. Three, the risk level associated with unsafe act on poor use of PPE, hot work operations, housekeeping, equipment handling and general workplace operations are High, hence, an electronic reporting tool for these behavioural safety observations was developed using the risk level of these various safety procedures.

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