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Identification of Industrial Hazards and Assessment of Safety Measures in the Chemical Industry, Nigeria Using Proportional Importance Index

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Authors' contributions

This work was carried out in collaboration among all authors. Author GCA designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Author ILN served as his major PhD supervisor and assisted in the study design and managed the analyses of the study. Author JNU assisted in PhD supervision and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Proper identification of hazards and creation of a safe working environment is a major challenge faced by management of many industries today. Hazard assessment is thus carried out in workplaces to identify dangerous events and conditions that may lead to accidents in the industries. This study, which was carried out in both a petrochemical and an oil refining companies of Nigeria, identified industrial hazards and assessed safety measures in the Chemical Industry (CHI) of Nigeria. A well-structured questionnaire instrument was used for data collection. The study was carried out amongst technical staff and management staff of the chemical industry whose day-to-day duty is such that they are exposed to one form of hazard or the other in the industry. The questionnaire was administered to 96 technical staff and management staff in the CHI out of which 84 (88%) were completed and returned. The study focused on types of hazards, hazards and risk

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awareness, implementation of control measures and effectiveness of safety hazards and risk management programmes in the chemical industry of Nigeria. Modified Proportional Importance Index (PII) and a four-point Likert scale were adopted in data analysis. Results revealed that loud noise (PII = 3.2; respondents = 92%), working at heights (with PII = 3.1; respondents = 89%) machines and equipment vibration (PII = 3.0; respondents = 87%), high voltage areas (PII = 2.9; respondents = 84%) and chemical spills (PII = 2.5; respondents = 55%) are the most high ranking hazards in the chemical industry. A high level of safety hazard awareness was found among workers in the industry ($p < 0.05$, 95%CI.; PII = 3.1 - 3.5). The outcome of the intervention showed that Chemical Industry Number 1 (CHI-1) improved from 87.90% to 98.09%, Chemical Industry Number 2 (CHI-2) improved from 81.53% to 95.54% on worker's knowledge on the identification and assessment of hazards and risk in the chemical industries. These hazards pose threats to the safety of workers and should be effectively controlled to reduce associated risks to as Low as Reasonably and Practically Achievable (ALARPA).

Keywords: Chemical industry; hazards; risk; proportional importance index; implementation.

1. INTRODUCTION

The surrounding work environment of any organization is made up of factors that directly or indirectly influence the behaviour of workers. It positively or negatively affects the safety of workers; however, the workplace environment is often overlooked in Nigeria [1]. The presence of hazards in any work environment is a potential source of danger with the likelihood of causing harm to workers. Thus, for any industry to achieve success, it must first conduct hazard and risk assessment to identify hazards that pose risk to workers in the work environment. Many workers in developing countries such as Nigeria are exposed to one form of industrial hazards or the other [2-3]. Workplace hazards are potential safety risks to workers with adverse consequences and thus must be identified and controlled in order to reduce the risks to As Low As Reasonably Possible (ALARP).

The chemical industry in Nigerian, such as petrochemical companies, is one of the largest industry involved in the production of ethylene, propylene, butadiene and other petroleum related products, which are used to manufacture secondary products such as plastics, soaps, detergents, and solvents for the general society [4-5]. The operations of the industry involve the use of machineries and equipment to transform raw materials into finished products. Various kinds of hazards have been identified within the work environment in the chemical industry of Nigeria [6]. Some of which include noise and vibration hazards, chemical hazards, fall from heights, biological hazards, electrical hazards, fire and explosion hazards [7]. These hazards pose a significant risk to workers in the industry [8]. The Chemical Industry (CHI) has been associated with an increasing risk of accidents due to these various hazards [9-10]. Most of these workplace hazards pose serious threats to workers [1]. Workplace hazards can result in fatal accidents, damage to machines and equipment and loss of productivity [1,11]. Such industrial accidents with adverse consequences can result in fatalities and disabilities [7,11]. A study by [7] reported high rate of fatalities in factories in Nigeria with chemical related activities being the highest. Ezenwa [7] in his study also reported that approximately 3,183 injuries occurred in Nigerian factories between 1987 and 1996, out of which about 2.2% was fatal. The chemical industry was said to account for 9.8% of the death of workers within this period. The hazards of high noise levels, explosion and working at heights have been found to be among the major causes of injuries and deaths in chemical industry in Nigeria [7, 12]. This study attempted to identify safety hazards and assess safety measures in the chemical industry of Nigeria using Proportional Importance Index (PII). The identification and assessment of potential hazards can be considered as a proactive way of achieving safety in the chemical industry. The study employed the PII derived from the Relative Importance Index (RII) by [13] to rank variables, identify potential hazards and assess safety measures in work environment in the chemical industry in Nigeria.

2. METHODOLOGY

After a preliminary survey of the companies to determine the total population of the study, a petrochemical company and an oil refining company were selected for the study because they shared similar characteristics in operations; they were treated as a single entity and thus referred to as the chemical industry (CHI). The study population included all the individuals in

the industry whose duties are such that they are exposed to hazards and risk in their workplaces or environment. This group of individuals consists of management staff and technical staff in safety, production, engineering and logistics departments from both companies. From the two companies, staff data recorded from departments exposed to safety hazards due to their daily activities are: Safety (10); Production (40); Engineering (25); and Logistics (15). A total of 80 staff (management and technical) each, given a total of 160 for the two companies was considered for the study. Hence, the total population is 160. The sample size for the study is a subset of the total population.

2.1 Sample Size Determination

After obtaining preliminary information on the study population, the sample size was determined using Equation (1) [14].

$$s = \frac{\chi^2 NP(1-P)}{d^2(N-1)+\chi^2 P(1-P)} \quad (1)$$

Where:

s = Required sample size;
χ^2 = Table value of chi-square for 1 degree of freedom at the desired confidence level;
N = Total population size = 160
P = Population proportion (assumed to be 0.50 since this would provide maximum sample size); and
d = Degree of accuracy expressed as a proportion (0.05).

Purposive sampling method [15-16] was adopted using well-structured questionnaire [17-19]. The computed sample size of 80 was obtained by Equation (1). However, in order to maintain the sample size (due to attrition rate) a factor of 20% was added to give 96. Based on computed sample size, a total of 96 staff participated from each CHI as 96 copies of questionnaire were self-administered to both management staff and technical staff of the CHIs out of which 84 (88%) were completed and returned as shown in Table 1.

2.2 Data Collection

The questionnaire was used to collect data on the socio-demographic feature of respondents, types of workplace hazards, awareness of safety hazards, implementation and effectiveness of hazards and risk control measures and programmes in the industry. Items in the questionnaire were grouped into five (5) sections (A - E). Section A was used to obtain socio-demographic data of the respondents; section B obtained information on the types of hazards in the CHI; section C assessed safety hazards and risk awareness levels among the respondents; section D evaluated the level of implementation of safety hazards and risk control measures in the CHI and section E assessed the effectiveness of safety hazards and risk management programmes in the industry. Items in the questionnaire were structured into four options of Strongly Agree (SA), Agree (A), Disagree (DA) and Strongly Disagree (SDA) with ratings as 4, 3, 2 and 1 respectively, assigned to each of the option. The participants were instructed to select one of the four options.

A walk through inspection survey was carried out as a follow-up on the questionnaire instrument. During the inspection exercise, a checklist was used to assess gaps in safety practices in the CHI. The inspection was carried out by Certified Inspectors in the selected CHI using modified inspection checklist to support data obtained from questionnaire. Machineries, equipment, and emergency and first aid practices/facilities were assessed. Also assessed were hazard communications process and usage of personal protective equipment, manual handling equipment, fire protection, housekeeping and workplace conditions. An intervention was then carried out through hazards awareness training in collaboration with HSE managers. The intervention was conducted in the CHIs as unsatisfactory levels of safety practices were observed. Two months intervention was carried out by the CHI safety managers through batch-wise awareness training of workers on identification of hazards and implementation of risk control measures; aimed at reducing the risk associated with some of the identified hazards. This was to increase awareness of technical staff and management staff on the hazards and risk especially on the identified high ranking hazards and to improve implementation of hazards and risk control measures such that hazards and risk management programmes in place will be more effective. A post-inspection survey was finally carried out to determine the expected level of improvement after intervention. The post-inspection which evaluated the impacts of the intervention programme on improving safety practices in the CHI was carried out two months after the intervention programme. The time lag between pre-inspection and post inspection was six months. The checklist used for the post inspection was analyzed.

Table 1. Questionnaire distribution and participants responses

Respondent	No. of questionnaires served	Completed and returned	Percentage (%) of respondents
CHI*-1 Management Staff	24	22	92
CHI-1 Technical Staff	24	20	83
CHI-2 Management Staff	24	24	100
CHI-2 Technical Staff	24	18	75
Total	**96**	**84**	**88**

CHI = Chemical industry*

Table 2. Proportional Importance Index (PII) scale and coding

	PII	Ranking	Comment/Code	Risk	Interpretation
1	1.0-2.0	5		Rare	Rare
2	2.1-2.5	4		Unlikely	Occasional
3	2.6-3.0	3		Possible	Sometimes
4	3.1-3.5	2		Likely	Often
5	3.6-4.0	1		Very Likely	Always

Source: [13]

2.3 Data Analysis

Collected data were aggregated, processed, coded and statistically analyzed using XLSTAT-2019 premium version software developed by [20]. Mann Kendall statistic was used to determine the level of agreement among the participants [21]. Cronbach's alpha coefficient formula [18,22] was used to determine the reliability of items in the questionnaire instrument. A modified four-point Likert scale was used to evaluate and analyze sections of the questionnaire instrument. Each questionnaire parameter was coded and assigned weights (4 to 1) based on the four-point Likert scale before analysis. Responses to each parameter were summed across the items to obtain a total impact score. A Proportional Importance Index (PII) (Equation 2) modified from the Relative Important Index [23-25] by [13] to evaluate hazards and safety practices in food and beverage industry in Nigeria was adopted and used in this study to evaluate and rank the scores of respondents as shown in Table 2.

$$PII = \frac{\sum_{i=1}^{n} F_i W_i}{\sum_{i=1}^{n} F_i} = \frac{F_1W_1 + F_2W_2 + F_3W_3 + ... + F_nW_n}{F_1 + F_2 + F_3 + ... + F_n}$$

For $(1 \le \mathrm{PII} \le 4)$. (2)

Where W = Likert weights given to each factor; F = frequency of respondents (score); n = maximum weight; i = 4, 3, 2 and 1; and $W_1 - W_4$ = 4, - 1.

3. RESULTS

3.1 Demographic Features of Respondents

The socio-demographic information of the respondents is presented in Table 3. The socio-demographic characteristics of the respondents indicated that 80% are male, while 20% are female. The age of respondents showed that 8% are below 25 years; 11% are between 25 and 30 years; 19% are between 31 and 35 years; 35% are between 36 and 40 years; while 27% are above 41 years. The qualifications of respondents indicated that 5% have diploma (OND) certificates; 55% have higher national diploma and first degree holders (HND/BSc); 39% have master's degree (MSc); while 1% has other degrees. About 80% of the respondents have full time employment; 11% are in part time employment; while 9% are casual workers. Assessment of working experience showed that 7% have worked for less than 1 year; 18% have worked between 1 and 5 years; 36% have worked for between 6 and 10 years; 22% have worked for between 11 and 15 years; while 17% have worked for 16 years and above. The assessment of the motivation for joining the chemical industry showed that 48% joined because of job security; 18% joined because of good salary; 9% joined because of lack of alternative job; while 25% joined because of good working condition.

Results of reliability test showed that sections B, C, D and E of the questionnaire instrument have

Cronbach's alpha coefficients of 0.88, 0.89, 0.91 and 0.97, respectively. These values are within the acceptable range of 0.8 and above [26-27].

3.2 Identification of Hazards in the CHI

The types of safety hazards in the CHI were evaluated and the results of respondents indicated that 55% agreed that some machines and equipment are faulty and not always in good working condition. On the issue of noise in the chemical industry, 92% of the respondents agreed that there is loud noise in their environment. On the issue of damaged electrical cables, 38% of respondents agreed that there are damaged electrical cables in the workplace. Concerning chemical spills, 55% of the respondents accepted that there are chemical spills within the environment. Regarding equipment vibration, most of the respondents (87%) consented that there is vibration from machines and equipment in the workplace. On the issue of high voltage, 84% opined that there are high voltage areas in the work environment. Concerning unguarded machineries, 35% of respondents accepted that there are unguarded machineries in the work environment. Regarding the issue of exposure to radiation, 44% of respondents agreed that there is exposure to radiation. The study also examined the storage of flammable materials and substances, and only 19% of respondents opined that flammable substances such as petrol, solvents and explosive chemicals are not properly stored. On the matter of lighting/visibility, 48% of the respondents agreed that there is poor lighting/visibility in the work environment. Regarding the issue of work at height, 89% of the respondents consented that some workers worked at height in the workplace. Finally, concerning flying cables and unwanted items, 34% opined that there are flying cables and unwanted items within the workplace.

The Kendall's Concordance Coefficient, W was computed to be 0.386, the Chi-Square (χ^2) value was computed to be 13.9 and the p-value was 0.003 ($p < 0.05$; 95%CI.) as shown in Table 4. The trend in agreement amongst the respondents on the types of hazards in the industry is shown in Fig. 1. The highest ranking hazards identified in the CHI based on the result of the respondents and PII are shown in Fig. 2. PII was used to evaluate and rank the hazards based on the outcomes of the respondents as presented in Table 5.

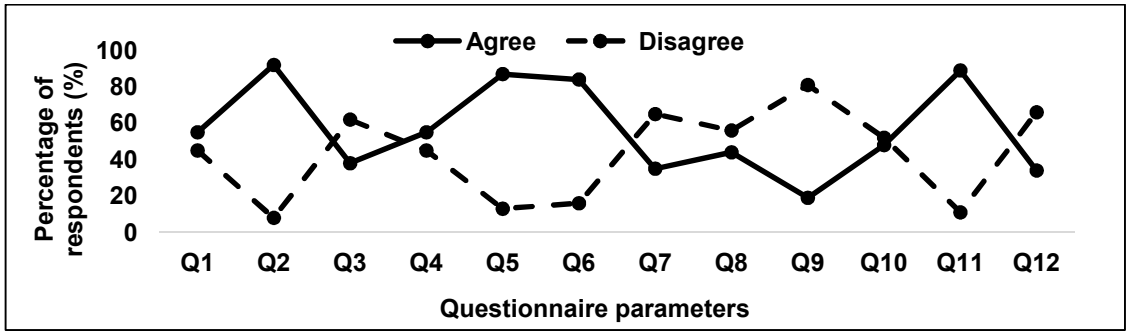

Fig. 1. Trend in responses by the participants on types of hazards in the CHI

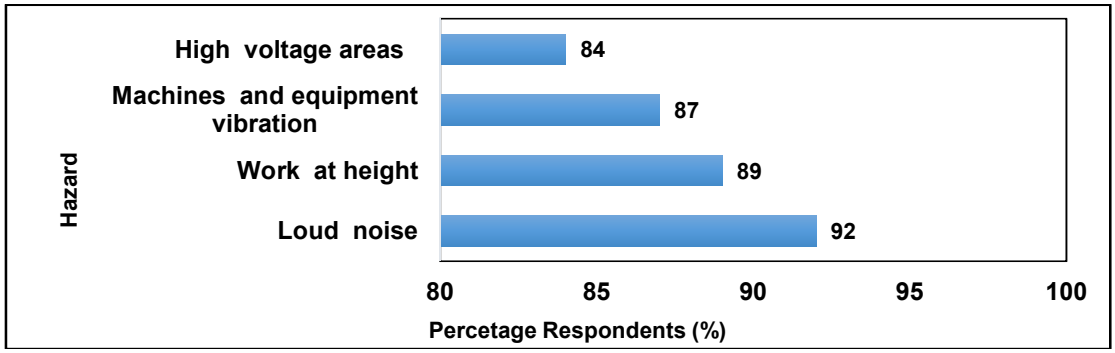

Fig. 2. Identified high ranking hazards in the CHI

Table 3. Socio-demographic characteristics of the respondents

Variable	Option	Frequency	Percentage (%)
Gender	Male	67	80
	Female	17	20
	Total	**84**	**100**
Age	Under 25 years	7	8
	25-30 years	9	11
	31-35 years	16	19
	36-40 years	29	35
	above 41 years	23	27
	Total	**84**	**100**
Educational qualification	Primary/Secondary		
	OND	4	5
	HND/BSc	46	55
	M.Eng/MSc	33	39
	Others	1	1
	Total	**84**	**100**
Employment status	Full time	67	80
	Part time	9	11
	Casual staff	8	9
	Total	**84**	**100**
Working experience	less 1 year	6	7
	1-5 years	15	18
	6-10 years	30	36
	11-15 years	19	22
	16 years & above	14	17
	Total	**84**	**100**
Job motivation factor	Job Security	40	48
	Good salary	15	18
	No job alternative	8	9
	Good Working conditions	21	25
	Other		
	Total	**84**	**100**

Table 4. Computed Kendall's concordance coefficient, W

Parameter	Questionnaire section			
	B	C	D	E
N	12	11	11	11
Kendall's W	0.386	0.898	0.958	1.0
Chi-square	13.9	29.636	31.624	33
Asymp. Sig.	0.000	0.000	0.000	0.000

3.3 Evaluation of Hazards and Risk Awareness of in the CHI

The awareness level of workers on safety hazards and risk in the CHI was examined. Result indicated that 100% of the respondents are familiar with workplace safety hazards and risk. Regarding safety policy, majority of the respondents (99%) consented that the companies have Occupational Safety Hazards and Risk Policy in place. On the awareness of the type of safety hazards and risk in the workplace, 99% stated that they are aware of the type of safety hazards and associated risks in the work environment; 97% confirmed that the companies run in-house training on safety hazards and risks; 85% also confirmed that the companies sponsor some staff for external training. Also, 96% consented that they are aware of safety hazards and risk drills organized in the companies; 89% indicated that they are familiar with the use of material safety data sheets in the companies; 98% agreed that they are familiar with hazards and risk control

measures used in the companies; on safety audit, 99% stated that they are aware of safety hazards and risk audits conducted in the companies; 88% confirmed that the companies have effective hazards and risk control mechanisms in place; while 98% believed that safety hazards can cause accidents in the workplace.

The computed Kendall's Concordance Coefficient was 0.898, the Chi-Square (χ^2) value was 29.636 and the p-value was 0.000 (p-value < 0.05; 95%Cl.) as shown in Table 4. The trend in the agreement amongst the respondents is shown in Fig. 3.The ranking of the hazards using proportional importance index is presented in Table 6.

3.4 Evaluation of Implementation of Hazards and Risk Control Measures in the CHI

The study also examined the implementation of safety hazards and risk control measures in the CHI. Results showed that 87% of the respondents agreed that they have received in-service training on safety hazards and risk in the last two years; 93% confirmed attending conferences, workshops and seminars; 84% agreed that management provides workers with operating safety manuals; 78% consented that supervisors usually conduct safety hazards and risk briefing with workers each day before start of work; 89% agreed that management carries out yearly in-house safety training for workers; 86% concurred that management sponsors staff for external training programmes on safety hazards and risk; 94% confirmed that management provides Personal Protective Equipment (PPE) for workers; while 99% confirmed that they make use of PPE issued to them. All the respondents (100%) confirmed that they usually follow safe work procedures while carrying out their duties; 73% agreed that management usually carry out prompt repairs of damaged equipment and electrical systems; while 86% confirmed that they often make use of Material Safety Data Sheets (MSDS) when handling chemicals.

Computed Kendall's Concordance Coefficient was 0.958, the Chi-Square (χ^2) value was 31.624 and the p-value was < 0.000 (p < 0.05, 95%Cl.) as shown in Table 4. The trend in agreement amongst the respondents on the implementation of safety hazards and risk control measures in the CHI is shown in Fig. 4. The ranking of the respondent's scores on the implementation of hazards and risk control measures using computed PII is shown in Table 7.

Table 5. Ranking of identified hazards in the CHI using PII

S/No	Parameter	PII	Occurrence	Rank	Interpretation
1	Some of the running machines and equipment are not always in good condition in your workplace.	2.5		4	Occasional
2	Occasionally, there is loud noise in your workplace.	3.2		2	Often
3	There are damaged electrical cables in your workplace.	2.4		4	Occasional
4	Chemical spills are seen within the workplace.	2.5		4	Occasional
5	There is vibration from equipment in your workplace.	3		3	Sometimes
6	There are high voltage areas in your company.	2.9		3	Sometimes
7	There are unguarded machineries in your workplace.	2.3		4	Occasional
8	There is exposure to radiation in your workplace.	2.2		4	Occasional
9	Flammable substances such as petrol, solvents and explosive chemicals are not properly stored in your company.	1.8		5	Rare
10	There is poor lighting/visibility in your company.	2.3		4	Occasional
11	Workers work at height in your workplace.	3.1		2	Often
12	There are flying cables and unwanted items (scarps) within the workplace.	2.1		4	Occasional

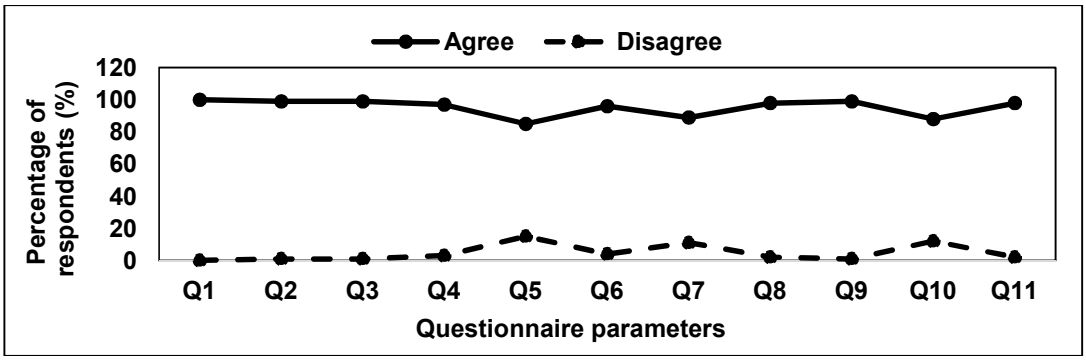

Fig. 3. Trend in responses by the participants on hazards and risk awareness in the CHI

Table 6. Ranking of assessment of hazards and risk awareness in the chiusing PII

S/No	Parameter	PII	Occurrence	Rank	Interpretation
1	You are familiar with workplace safety hazards and risk.	3.4		2	Often
2	Your company has Occupational Safety Hazards and Risk Policy.	3.5		2	Often
3	You are aware of the type of safety hazards and risk associated with your line of duty	3.5		2	Often
4	Your company regularly runs in-house safety hazards and risk training programme at least once a year.	3.3		2	Often
5	Your company also sponsors staff for external training programme on safety hazards and risk at least once a year.	3.1		2	Often
6	You are aware of the safety hazards and risk drills carried out in your company.	3.5		2	Often
7	You are familiar with the use of Material Safety Data Sheets (MSDS) in your company.	3.2		2	Often
8	You are very familiar with hazards and risk control measures used in your company.	3.2		2	Often
9	You are conversant with safety hazards and risk audit conducted in your company.	3.3		2	Often
10	Your company has effective hazards and risk control mechanism in place.	3.2		2	Often
11	Safety hazards can cause accident(s) in the workplace.	3.3		2	Often

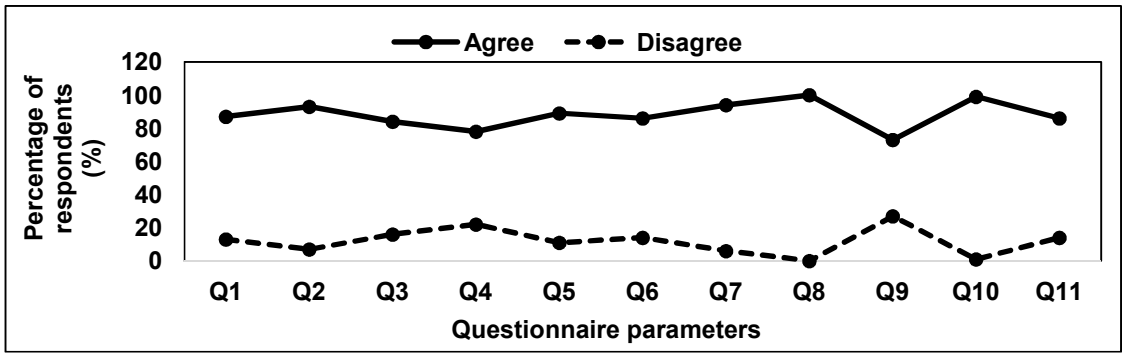

Fig. 4. Trend in responses by the participants on the implementation of hazards and risk control measures in the CHI

Table 7. Ranking of the implementation of hazards and risk control measures in the CHI using PII

S/No	Parameters	PII	Occurrence	Rank	Interpretation
1	You have received in-service safety hazards and risk training in the last two years.	3.2		2	Often
2	You have attended conferences, workshops or seminars on safety hazards and risk since you were employed.	3.2		2	Often
3	Management provides workers with operating safety manuals.	3.1		2	Often
4	Supervisor usually conducts safety hazards and risk briefing with workers each day before start of work.	3		3	Sometimes
5	Management carries out in-house safety hazards and risk training programme for workers every year.	3.1		2	Often
6	Management also sponsors staff for external training programme on safety hazards and risk every year.	3.1		2	Often
7	Management provides suitable Personnel Protective Equipment (PPE) for workers.	3.3		2	Often
8	You usually follow safe work procedures while carrying out your duties.	3.4		2	Often
9	Your company usually carries out prompt repairs of damaged equipment and electrical systems.	2.9		3	Sometimes
10	You regularly make use of the PPE provided for you while carrying out your duties.	3.6		1	Always
11	You always make use of Material Safety Data Sheets when handling chemicals.	3.2		2	Often

3.5 Evaluation of the Effectiveness of Hazards and Risk Management Programmes in CHI

The study equally assessed the effectiveness of safety hazards and risk management programmes in the CHI. The results indicated that 92% of the respondents agreed that the use of operating safety manual has helped in minimizing accident in the companies; 97% consented that the participation in Health Safety and Environment(HSE) training/workshop/ seminar programmes has increased the knowledge on safety hazards and risk in the workplace; 92% accepted that the use of MSDS has helped in minimizing chemical spills and exposure in the companies; 96% concurred that the use of PPE has assisted in reducing cases of accidents in the companies; most of the respondents (96%) confirmed that outcomes of the safety hazards and risk programmes have helped in minimizing hazards and risk in the companies; 96% of respondents agreed that the conduct of safety hazards and risk audit has assisted in identifying and minimizing potential hazards in the work environment; majority of the respondents (94%) consented that the methods used to control hazards and risk have helped to protect workers and reduce accidents and injuries among workers; 94% agreed that compliance to safe work procedures has reduced workplace accidents; 89% accepted that prompt repairs of damaged machines/equipment and electrical systems have helped in reducing cases of accidents in the workplaces; 96% concurred that the conduct of regular safety meetings has assisted in improving safety practices among the workers; finally, 96% confirmed that the conduct of regular safety hazards and risk audits have helped in identifying areas of safety hazards and risk weakness in the companies.

Also, computed Kendall's Concordance Coefficient was 1.0, the Chi-Square (χ^2) value was 33.0 and the p-value was < 0.0001(p-value < 0.05; 95%CI) as shown in Table 4. The trend amongst the respondents on the effectiveness of safety hazards and risk management programmes in the CHI is shown in Fig. 5; while the ranking of respondents' scores using PII is shown in Table 8.

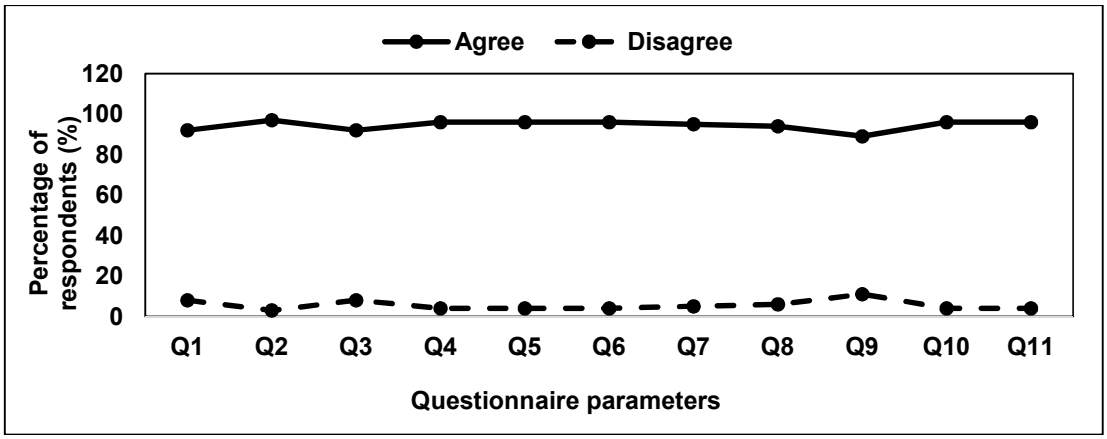

Fig. 5. Trend in responses by the participants on the effectiveness of hazards and risk management programmes in the CHI

Table 8. Result of PII on the effectiveness of hazards and risks control programmes in the CHI

S/No	Parameters	PII	Occurrence	Rank	Interpretation
1	The use of operating safety manual has helped to minimize accident cases in your company.	3.2		2	Often
2	Participation in HSE training/workshop/seminar programmes has increased your knowledge on safety hazards and risk in the workplace.	3.4		2	Often
3	The use of Material Safety Data Sheets has helped in minimizing chemical spills and exposure in your company.	3.2		2	Often
4	Use of Personnel Protective Equipment (PPE) has assisted in reducing cases of accidents in the company.	3.4		2	Often
5	Outcomes of the safety hazards and risk programmes have helped to minimize hazards and risk in your company.	3.3		2	Often
6	The conduct of safety hazards and risk audits has assisted in identifying potential hazards in the work environment.	3.4		2	Often
7	Methods used to control hazards and risks have helped to protect workers and reduce cases of accidents and injuries among workers.	3.3		2	Often
8	Compliance to safe work procedures while carrying out your duties has reduced workplace accidents arising from negligence to safe operations.	3.2		2	Often
9	Prompt repairs of damaged machines/equipment and electrical systems have reduced cases of accidents arising from machines and electricity in the workplace.	3.2		2	Often
10	The conduct of regular safety meetings has assisted in improving safety practices among workers.	3.3		2	Often
11	Regular safety hazards and risk audits have helped in identifying areas of safety hazards and risk weakness in the company.	3.3		2	Often

Table 9. Pre – and post-inspection checklist analysis

Pre-inspection			Post inspection		
	CHI-1	CHI- 2		CHI- 1	CHI- 2
TS	138	128	TS	154	150
TU	19	29	TU	3	7
TS + TU	157	157	TS + TU	157	157
% S*	87.90	81.53	% S*	98.09	95.54
% U*	12.10	18.47	% U*	1.91	4.46

% S = Percentage Satisfactory = [(TS/(TS+TU))*100](6)*
% U = Percentage Unsatisfactory = [(TU/(TS+TU))*100](7)*

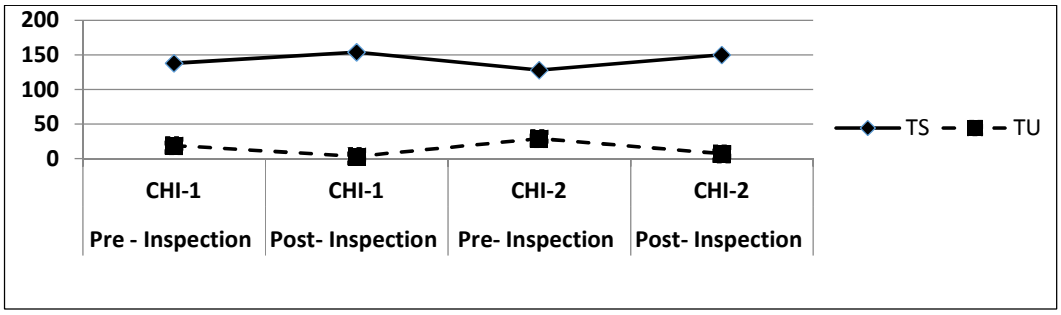

Fig. 6. Trend in the level of improvement after intervention

3.6 Impact of Intervention Programme on Hazards Identification and Risk Control Measures in the CHI

The study carried out a walk through inspection to support the data from questionnaire and unsatisfactory levels of existing hazards for both CHIs was significant (Table 9), which triggered the need for intervention awareness on the assessment of hazards and risk. The results of the pre-inspection and post intervention are presented in the Table 9. After the pre-inspection, a higher level of Satisfactory (S) performance was seen for CHI-1 from the pre-inspection checklist analysis carried out (Table 9). Reasonable levels of Unsatisfactory (U) performance was observed for both CHIs especially CHI-2. After the intervention, CHI-1 improved from 87.90% to 98.09%; CHI-2 improved from 81.53% to 95.54% and the trend of the level of improvement (Fig. 6).

4. DISCUSSION

4.1 Respondents Characteristics

The result indicates that majority of the staff in the chemical industry are male, which implies that the male gender dominates the chemical industry in Nigeria. This result agrees with findings by Chineke et al., Okafoagu et al. [2-3] who in their various studies found that there are more males in chemical related industries than females. Also the International Labour Organization [28] reported low participation of females in the oil and gas industry in Sub-Saharan African countries. This could be attributed to the fact that the operations and activities in the industry is labour intensive. The age of the respondents shows that the majority of them are adults and are better informed on industrial hazards and control measures; this corroborated findings by Takele and Abera, [29-30]. It was found that majority of the respondents are well educated, this level of education may influence their knowledge of hazards and risk in the industry. This finding agrees with studies by [3] who in their study found a significant relationship between levels of education and attitude of workers towards workplace hazards in a chemical industry in Nigeria. The study also found that majority of the respondents has permanent employment and have long years of working experience. They actively participate in safety programmes and thus are very familiar with industrial hazards and risk management programmes in the industry. According to [3], this positively influences their knowledge and behavior towards workplace hazards. Different factors were responsible for the respondents joining the chemical industry, however, job security and good working conditions were found to be the most attractive factors responsible for many of them joining the industry. This implies

that most of respondents hope to secure their jobs up to retirement, this finding corroborated study by Afube et al. [13].

4.2 Identification of Safety Hazards in the CHI

There was no explicit trend in agreement among the participants on the types of hazards identified in the chemical industry. However, evaluation of respondents' scores using PII indicates that the hazards of loud noise and working at heights occurred frequently in the chemical industry. Loud noise, vibration, working at heights and high voltage areas was found to be the major hazards that pose serious risk in the industry. Other hazards that are occasionally encountered in the industry are faulty machines and equipment, damaged electrical cables, chemical spills, radiation, flammable substances and explosive chemicals. These hazards also constitute significant risk in work environment. These findings corroborated with results of similar studies [1,6-7,12,31-32].

4.3 Safety Hazards and Risk Awareness in the CHI

The level of agreement among the respondents on the awareness of safety hazards and risk in the chemical industry was highly significant. This may be attributed to the Safety Management System (SMS) in place in the companies; creating high level of awareness among the workers. Evaluation of the level of awareness of safety hazards amongst the respondents using PII indicates that the workers are often aware of hazards in their work environment. This finding agrees with the results of Okafoagu and Olayinka [3,33] who in their studies reported that majority of the workers in chemical related industries in Nigeria are aware of safety measures in their workplaces. The study found that the workers in the CHI received adequate training on safety hazards; this finding contradicts the finding by Awodele, [30] who reported that only about 30% of workers in a paint factory in Nigeria received training on hazards and safety measures.

4.4 Implementation of Safety Hazards and Risk Control Measures in the CHI

A high degree of agreement was obtained amongst the respondents on the implementation of safety hazards and risk control measures in the chemical industry. Occupational safety hazards and risk policies are implemented, in-house safety audits are carried out on a regular basis, while general audits are conducted as at and when due by certified safety auditors. This study found that workers in the chemical industry often received in-service training on safety hazards and risk, attend workshops and seminars. These findings are similar to the finding by Ezenwa, [7] who reported that the majority of the workers in a chemical related industry had a formal training on safety hazards; however, it contradicts the finding by Awodele, [30] who reported that only about 30% of workers in a paint factory in Nigeria received training on hazards and safety measures. It also contradicts findings of Okafoagu et al., Eguvbe et al. [3,12] who in their studies reported poor safety practices and poor training of workers in chemical related industries in Nigeria. The study also shows that management often provide operating safety manuals, PPE for workers and carries out in-house safety hazards and risk training for workers. It further reveals that workers always make use of PPE provided by management. This finding is contrary to result by Chineke et al. [2] who in their study reported that adequate PPE are not provided for workers in petroleum-allied industries in Nigeria. It was further discovered that management sometimes carries out prompt repairs of damaged equipment and electrical systems.

4.5 Effectiveness of Safety Hazards and Risk Management Programmes in the CHI

There is a mutual perfect degree of agreement amongst the respondents on the effectiveness of safety hazards and risk management programmes in the chemical industry. The study found that the use of operating safety manual has helped in minimizing accidents; participation in HSE training/workshop/seminar programmes helped increased the knowledge of the workers on safety hazards and risk in the workplace; the use of PPE helped to protect workers and reduce accidents and injuries amongst the workers and minimized chemical exposure. The methods used to control hazards and risk have helped to reduce cases of accidents in the industry; the regular conduct of safety hazards and risk audits have helped to identify and minimize potential hazards in the work environment. The study further found that management often carry out prompt repairs of breakdown machines/ equipment and electrical systems, while compliance with safe work procedures by the workers often help in reducing hazards and risks in the chemical industry.

4.6 Intervention on Hazards and Risk Control Measures in the CHI

The study carried out a walk through inspection to support the data from questionnaire. After the pre-inspection, high level of Satisfactory (S) performance was seen from initial checklist inspection analysis carried out. However, reasonable levels of Unsatisfactory (U) were observed especially for CHI-2, which triggered the need for intervention (awareness training and implementation of control measures) to see the level of expected improvement. Post inspection was carried out after the intervention process in the CHI. A significant level of improvement was obtained after the intervention awareness on the assessment of hazards and risk. This finding corroborated with the result of the study [34] who reported in their study that there was significant positive contribution of safety awareness intervention on the attitude of workers toward occupational hazards and risk.

5. CONCLUSION

The study evaluated industrial hazards and safety measures in the chemical industry in Nigeria. The hazards of loud noise, chemical spills, working at heights, equipment vibration and high voltage areas were identified as major hazards that posed risk to workers in the chemical industry in Nigeria. Workers in the industry demonstrated high level awareness and good knowledge of safety hazards as a result of the effective implementation of safety policies and programmes by management of the industry. The study reveals that management always provide PPE and carry out safety hazards and risk training for workers as well as ensure compliance to safety policies and programmes. Intervention carried out further improved workers' knowledge on safety hazards and risk control measures in the CHI. To further maintain safe working environment in the chemical industry of Nigeria, management should develop a safety management system based on ISO 31000 and ensure compliance to international best safety practices.

6. LIMITATIONS OF THE STUDY

The following limitations were encountered in the course of the study:

1. Initially, it was difficult to obtain the approval of management to carry out the study; however it was approved after a mutual agreement on ethical terms;
2. It was impossible to achieve 100% retrieval of questionnaires submitted as some of the respondents were not available during the retrieval period. Only 88% was retrieved though rate of response was sufficient and provided ample proportion of data for analysis and interpretation;
3. Time to carry out initial intervention was one month but extended to two months as the selected chemical industries were in full control.
4. It took time to reach an agreement and execution of the inspection for each of the selected CHI by the Certified Auditors as they were not readily available due to their previous engagements with other clients; and
5. The respondents were unwilling to participate with the excuse they do not have time, but they were clarified on the simplicity of the items in the questionnaire. They were further educated on the importance of research before the exercise and assured them of confidentiality.

CONSENT

The consent of the study population was obtained before embarking on data collection with an official formal letter addressed to the management of the studied chemical companies. The management and workers were assured of the confidentiality of the data and information given by the participants. In view of this, it was agreed that the two chemical companies considered in this study be coded as CHI-1 and CHI-2. Thus, due process was followed in the data gathering process of the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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