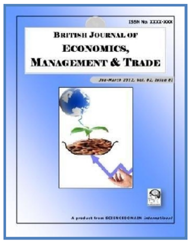

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Perception Survey of the Impact of Behaviour Based Safety on Accident Prevention in the Bonny NLNG Construction Project, Nigeria

M. O. Agwu[1*]

[1]*Department of Business Administration, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.*

Author's contribution

Author MOA designed and carried out the research, performed the statistical analysis, wrote, read and approved the final manuscript with the assistance of SDI reviewers' and guides for final editing.

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ABSTRACT

The paper is a perception survey of the impact of behaviour-based safety (BBS) on accident prevention in the Bonny NLNG construction project. It defines BBS as an accident preventive progamme designed to change employees behaviours from "at risk" to "safe" behaviours using both positive and negative reinforcements. The research question addressed the extent at which reduction of workers at-risk behaviours and accident rate is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project. It assumes that majority of work related accidents are caused by workers at-risk behaviours which can be reduced through behaviour modification. An exploratory cross-sectional employees' perception survey was used in conducting the study, using questionnaire administered on 384 randomly selected employees of the ten construction companies involved in the Bonny NLNG construction project. The questionnaire responses were presented using tables, analyzed using simple percentages while formulated hypotheses were tested using chi-square (χ^2).The results indicated that the implementation of behaviour-based safety programme in the Bonny NLNG construction project to a large extent reduced workers at-risk behaviours and accident rate. The research concludes that reduction in workers at-risk behaviours and accident rate is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project. It therefore recommends among others: a

**Corresponding author: Email: mbaagwu38@yahoo.com;*

continuous review of employees behaviour reinforcement techniques, encouragement of workers to observe/correct each other's at-risk behaviours, provision of extensive training for B-Safe observers and continuous commitment of management/workers to the elimination of at-risk behaviours in the workplace.

Keywords: Behaviour-based safety; at-risk behaviours; behaviour reinforcement; accident prevention.

1. INTRODUCTION

The idea of executing a liquefied natural gas project was first conceived by the Nigerian government in 1966, sequel to a request for natural gas supply by the European Union to augment its supply shortfall. But the absence of a steady and stable natural gas market coupled with other socio-economic and political factors delayed the early take-off of the project. The discovery of a large and stable natural gas market, in the Pacific Rim and the Atlantic Basin, in the late 80's by the Nigerian National Petroleum Corporation (NNPC), rekindled the interest of the Federal Government in the liquefied natural gas (LNG) project. The need to diversify the mono-product economic base of the nation and harness its vast natural gas resources and reduce gas flaring led to the incorporation of the Nigeria Liquefied Natural Gas (NLNG) company in May 17, 1989 [1]. The NLNG is jointly owned by the Nigerian National Petroleum Corporation (49%), Shell Gas BV (25.6%), Totalfinaelf (15%) and Eni International BV (10.4%). Its mission is to liquefy and export natural gas from the onshore concession areas of the Eastern part of the Niger Delta, where about 50% of Nigeria's proven and probable natural gas reserves are located. Nigeria's gas potentials are estimated at about 140 trillion standard cubic feet, about 27 billion barrels crude oil equivalent [2].In order to realize the company's objective, the shareholders in November 1995, took a final investment decision to build a $3.8 billion Liquefied Natural Gas plant in Finima, Bonny Island, Rivers State [3]. In December 1995, a consortium of engineering firms comprising Technip, Snamprogetti, M.V. Kellogg and Japan Gas Corporation (TSKJ) was awarded a Turnkey Engineering, Procurement, Installation and Construction (EPIC) contract, for the construction of the plant, the gas transmission system and the residential area. TSKJ as an engineering design consortium engaged the services of construction firms (Julius Berger Nigeria PLC, Daewoo Engineering and Electrical Construction Company, Fougerolle Nigeria Limited, Cimimontubi Nigeria, DBN Nigeria Limited, Spibat Nigeria Limited, Bouygues Nigeria Limited, Chicago Bridge and Iron Company Limited, Dumez Nigeria 58 Limited and Etco Nigeria Limited).To ensure a safe work environment with zero accident/incident rates for the construction workforce, a safety management system with emphasis on changing workers at-risk behaviours (behaviour- based safety) was incorporated into the project design and construction contract document in accordance with the provisions of the Mineral Oils (Safety) Regulations [4].The phrase "behavior-based safety" (BBS) was coined by Dr. E. Scott Geller of Safety Performance Solutions (SPS) in 1979 [5]. It is an accident preventive progamme designed to change employees behaviours from "at risk" to "safe" behaviours using both positive and negative reinforcements. Its focus is on modifying the behavior of workers in order to prevent occupational injuries and illnesses since 88% of all industrial accidents/incidents are primarily caused by workers at-risk behaviours/unsafe acts [6]. The researcher adopts a management/employee partnership approach to behaviour-based safety which emphasizes the collective efforts of both management and workers in the identification and elimination of at-risk behaviours in the workplace. The research only covered the NLNG trains 4, 5 and 6 projects with emphasis on site supervisors, foremen and workmen who are directly involved in construction activities.

1.1 Statement of the Problem

Since inception in 1996, the NLNG construction project with an average workforce of 9,566 persons records an average of 1 fatality, 10 medical treatment cases, 15 first aid cases, 20 near-misses and 50 unsafe acts per annum which is quite infinitesimal considering the magnitude of the workforce and the global construction industry accident statistics [7].The occurrence of accidents in construction sites usually leads to site closure for accident investigation, loss of man/machine hours, loss of output, high labour turnover, loss of corporate reputation, payment of medical expenses of the injured and payment of compensation/insurance claims for the dead/injured. Economic development activities are usually hampered in a country with high rate of construction accidents; since productivity/national output will be low, inflation and rate of unemployment will be high while there will be an increase in social vices. Since accidents originate from the at-risk behaviours of people, they can be prevented through the identification and elimination of these behaviours via a management/employees driven behaviour- based safety programme that is deeply rooted in antecedents- behaviour consequence model especially in the Bonny NLNG construction project.

1.2 Research Objectives

The objectives of the research are as follows:

1. To determine the extent at which reduction of workers at-risk behaviours is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.

2. To determine the extent at which accident rate reduction is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.

1.3 Research Questions

The identified gap of ineffectiveness in previous behaviour-based approaches to safety, which were either management or employee driven, propelled the development of the management/employees partnership approach to behaviour-based safety in the construction industry thus prompting the following research questions:

1. To what extent is reduction of workers at-risk behaviours dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project?

2. To what extent is accident rate reduction dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project?

1.4 Research Hypotheses

In view of the above research questions, the following null hypotheses were formulated:

$1H_O$: Reduction of workers at-risk behaviours is not dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.

$2H_{o:}$ Accident rate reduction is not dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.

2. LITERATURE REVIEW

Historically, organizations have focused on improving safety by addressing the work environment surrounding employees, providing hazard-free facilities, providing better tools and equipment without achieving any appreciable reduction in the rate of accidents. They have come to realize (or be reminded) that (1) people are not perfect and will make mistakes despite their best intentions and working in the best of surroundings, and (2) the work culture often allows or encourages at-risk behaviors to be performed. Thus, behaviour-based safety has become a popular way of managing the people side of safety since it revolves around what motivates and reinforces people's behaviour. Behaviour-based safety has many advocates and critics. Advocates have seen or experienced the effects of a well-designed process on incident rates [8].Conversely; critics do not believe it truly involves workers in the overall safety process [9], while some critics believe the concept has run its course [10]. The promotion of operant theory [11] within the behavioral safety field [12,13,14] has led many to believe that the antecedent-behavior-consequence model focuses almost exclusively on the psychology of safety especially in the construction industry. In reality, like other safety management programmes, behaviour-based safety requires the concerted effort of both management and employees to produce desired results. Since its inception and application in the mid- 1970s, behaviour-based safety, has undergone a series of evolutionary changes. The first approach, popular in the early 1970s to mid-1980s, was largely a supervisory top-down-driven process, based on operant theory [15]. In this approach, supervisors observed their workers behaviour, gave feedback and provided some form of positive or negative reinforcement. It is important to note that behaviour change did not last once reinforcers were removed. Though this concept is simple and cheap to implement, it attracted legitimate criticisms that has since been hard to dispel [16].Perhaps as a reaction to those criticisms, employee- led approach emerged in theearly'80s. In this approach, employees developed the overall process, conducted peer-to-peer or workgroup-based observations and provided feedback. However, the demerit of this approach is the exclusion of management, thus leading to the common perception that behaviour-based safety focused solely on employee behavior [17]. This led, in the 1990s, to the cultural approach based on the concept of management and employee partnership. In this approach, employees monitor the behaviour of all members of a workgroup or work area while managers regularly monitor their own safety-related leadership behaviors. Everyone involved receives regular feedback while some also received tangible reinforcers or incentives [18].Surveys of behaviour-based safety users show that all three approaches are widely used around the world [19].Each has tried to address the most efficient way to design the process to produce positive results in a cost-effective manner. Sulzer-Azaroff and Austin [20] stated that the effectiveness of the various approaches is often dictated by the purpose of implementation.

They cited variations in observation, frequency and mechanisms of feedback, priorities, support structures and roles of key personnel as factors that account for the choice of each approach.

2.1 Conceptual Framework

Behavior-based safety originated from the work of Herbert William Heinrich in the 1930s, who reviewed thousands of accident reports completed by supervisors of Traveler's Insurance Company and concluded that roughly 90% of all accidents, illnesses and injuries in the workplace are directly attributable to "man-failures" or at-risk behaviours of workers. This conclusion became the foundation of what BBS has come to be today. BBS addresses the fact that there are additional reasons for injuries in the workplace: environment, equipment, procedures and attitudes. Behavioral Science Technology (BST), pioneers in applying BBS processes, expanded on this work and identified the "working interface", as the point where exposure to injury occurs. BBS is designed to change employees behaviours from “at risk” to “safe” behaviours using both positive and negative reinforcements by focusing and analyzing what people do and applying a research-supported intervention strategy for improvement. It is not based on assumptions, personal feelings or common knowledge but on scientific knowledge. It is also an excellent tool for collecting data on the quality of a company’s safety management system and an effective step in creating a truly proactive safety culture where loss prevention is a core value. It is easy to understand but often hard to implement and sustain.

Given the prominence of at-risk behaviours in the accident pyramid/preventive process shown in Figs. 1 and 2 below, it is not surprising that safety improvements focused on individual behaviours have acquired popularity in the evaluation of organizational safety performance [21]. However, the implementation and sustainability of such programmes have been variable and many successful programmes that have reportedly improved health and safety performance have seemingly lost momentum [22]. It is important to note that the concept of behaviour change is intimately tied up with issues of motivation, attitudes, beliefs, learning and trust that are influenced by the organizational safety culture.

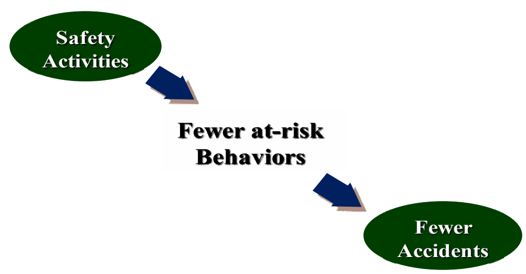

Fig. 1. Heinrich accident pyramid **Fig. 2. Heinrich accident preventive process**

Source: Heinrich, H.W. Industrial accident prevention: A Scientific approach. New York: McGraw-Hill, 1950

For any behaviour-based safety programme to achieve a change in behaviour there is need for a change in the company policy, procedures and organizational system and support from all employees, from the CEO to the shop floor staff. An ideal BBS programme should consist of the following steps: •Identify unsafe behaviors (obtained from injury and near-hit incident records), •Develop appropriate observation checklists (which feature behaviours implicated in injuries), •Educate everyone (tell and sell to all and train observers, facilitators and champions), •Assess ongoing safety behaviour by conducting behavioural observations and provide limitless feedback-verbal, graphical and written on results [23].

2.2 Theoretical Framework

The goal of behaviour-based safety is to change the behaviour of employees from “at risk” to “safe” behaviours. A common phenomenon of this research and previous behaviour- based research findings is that human errors (at-risk behaviours/unsafe acts) are fundamental to the occurrence of accidents. This research is based on Boyce & Roman [24] theory that frequencies of illness and injury in the workplace can be decreased through modification of workers behaviours by focusing management attention on unsafe acts committed by workers. The study assumes a causal relationship between at-risk behaviours and the occurrence of workplace accidents and that the latter can be prevented through the manipulation of the former using the Antecedent Behaviour-Consequence (ABC) model. The ABC model propounded by B.F. Skinner [25] assumes that all behaviours emanate from antecedents and consequences. Antecedents serve as triggers to observable behaviours while consequences either enforce or discourage repetition of the behaviours.

2.3 Behaviour-Based Safety Methodology

The basic process of a behaviour-based safety programme consists of identifying and encouraging observable safe behaviours and its antecedents (activators) using positive consequences (reinforcements/rewards) and using negative consequences (punishment) to discourage unsafe behaviours [26].The goal is for management to set up a system that will control the antecedents and consequences of workers behaviours. The assumption being that a well-planned system of antecedents and consequences will control unsafe behaviors thus preventing accidents. Furthermore, behaviourists believe that consequences are the driving force for changing people’s behaviour. Hence, positive and negative reinforcement’s tools are required to make people behave in the prescribed manner.

According to Cooper [27], the core features of a BBS process are as follows:

- Observation of workers by workers.
- Provision of extensive training for observers.
- Development of a list of "critical worker behaviours" often with input from workers.
- Development of ‘model safe behaviours’ so that workers’ behaviours are measured against their own standards – i.e. past behaviours.
- Substantial management commitment, including financial.
- Institution of reward systems e.g. bonuses or acknowledgement of efforts.
- Promotion of BBS as a ‘voluntary’ participatory company-wide programme.
- Utilization of current participative and representative structures e.g. elected safety representatives, union delegates, and safety committees.

3. RESEARCH METHODOLOGY

The scope of the research is limited to the ten construction companies (Julius Berger Nigeria Plc, Daewoo Engineering and Electrical Construction Company, Fougerolle Nigeria Limited, Cimimontubi Nigeria, DBN Nigeria Limited, Spibat Nigeria Limited, Bouygues Nigeria Limited, Chicago Bridge and Iron Company Limited, Dumez Nigeria Limited and Etco Nigeria Limited) that are involved in the construction of NLNG trains 4, 5 and 6 projects with emphasis on site supervisors, foremen and workmen who are directly involved in construction activities. An exploratory, cross-sectional perception survey was used in generating the primary data required for the study. The population of study consists of 9,566workers of three categories (280 supervisors, 830 foremen and 8,456workmen) drawn from the ten construction companies involved in the construction of NLNG trains 4, 5 and 6 projects. A sample of 384 workers (11supervisors, 33 foremen and 340 workmen) determined at 5% level of significance for sample error, using Taro Yamane’s [28] formula, was selected using stratified random sampling method for the purpose of questionnaire administration. The questionnaire was designed to obtain a fair representation of the opinions of the three categories of workers involved in the construction of NLNG trains 4, 5 and 6 projects using a three-point Likert type scale. The questionnaire responses of the sample respondents were presented using tables, analyzed and interpreted using simple percentages. A total of 384 copies of the 260 questionnaire were administered, out of which 2 were cancelled while 2 were also not returned and 380(99%) were used for the analysis.

4. RESULTS AND DISCUSSIONS

4.1 Distribution of Sample Respondents

The distribution of sample respondents among the three categories of workers in the ten construction companies involved in the construction of NLNG trains 4, 5 and 6 projects is as shown in Table 1 below:

Table 1. Distribution of sample respondents among NLNG construction companies

S/No	Name of company	Sample supervisors	Sample foremen	Sample workmen	Total number of sample respondents
1.	Julius Berger Nigeria PLC	2	4	57	63
2.	Daewoo engineering and electrical construction company	1	4	50	55
3.	Fougerolle Nigeria limited	1	4	35	40
4.	Cimimontubi Nigeria limited	1	3	30	34
5.	DBN Nigeria limited	1	3	30	34
6.	Spibat Nigeria limited	1	3	35	39
7.	Bouygues Nigeria limited	1	3	21	25
8.	Chicago Bridge and iron company limited	1	3	28	32
9.	Dumez Nigeria limited	1	3	30	34
10.	Etco Nigeria limited	1	3	20	24
	Total number of sample respondents	11	33	336	380

Source: Field survey, 2012.

4.2 Distribution of Responses on Research Questions

The sample responses of the three categories of workers (supervisors, foremen and workmen) in the ten construction companies involved in the execution of the NLNG project is as summarized in Table 2 below:

Table 2. Summary of sample responses on research questions

S/No	Research questions	Large extent	Mild extent	Poor extent	Total responses
1.	To what extent does your company implement BBS in the execution of the NLNG construction project?	300	60	20	380
2.	To what extent has the implementation of BBS contributed to the reduction of workers at-risk behaviours in your company?	250	100	30	380
3.	To what extent has the implementation of BBS contributed to the reduction of accident rate in your company?	225	115	40	380
4.	To what extent are reduced workers at-risk behaviours dependent on the implementation of BBS in your company?	245	110	25	380
5.	To what extent is reduced accident rate dependent on the implementation of BBS in your company?	240	100	40	380

Source: Field survey, 2012.

The computation of the observed and expected frequencies for questions 4 and 5 are as shown in Tables 3 and 4 below:

Table 3. Observed and expected frequencies of question number 4

Category of respondents/workers	Responses provided			
	Large extent	Mild extent	Poor extent	Total
Supervisors	8(7.09)	2(3.18)	1 (0.72)	11
Foremen	13(21.28)	10(9.55)	10(2.17)	33
Workmen	224 (216.63)	98 (97.26)	14 (22.11)	336
Total	245	110	25	380

Source: Field survey, 2012.

Table 4. Observed and expected frequencies of question number 5

Category of respondents/Workers	Responses provided			
	Large extent	Mild extent	Poor extent	Total
Supervisors	9(6.95)	1(2.89)	1 (1.16)	11
Foremen	12 (20..84)	7(8.68)	14(3.47)	33
Workmen	219(214.17)	92 (88.42)	25 (35.37)	336
Total	240	100	40	380

Source: Field survey, 2012.

4.3 Test of Hypotheses

4.3.1 Test of the first hypothesis

I. **H_O:** Reduction of workers at-risk behaviours is not dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.

II. **H_1:** Reduction of workers at-risk behaviours is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.
III. α =0.05.
IV. Degree of Freedom (df) = (r – 1)(c-1= (3-1)(3-1)=4.
V. Chi- square critical table value $(\chi^2_t) = \chi^2_{0.05} = 9.49$.

Table 5. Computation of Chi-square critical computed value (χ^2_c) from Table 3

Fo	Fe	(Fo-Fe)	(Fo-Fe)/Fe	$(Fo-Fe)^2/Fe$
8	7.09	0.91	0.1283	0.0165
2	3.18	-1.18	-0.3711	0.1377
1	0.72	0.28	0.3889	0.1512
13	21.28	-8.28	-0.3891	0.1514
10	9.55	0.45	0.0471	0.0022
10	2.17	7.83	3.6083	13.0198
224	216.63	7.37	0.0340	0.0012
98	97.26	0.74	0.0076	0.0001
14	22.11	-8.11	-0.3668	0.1345
				χ^2_c=13.6146

(vi) **Decision Rule**: Reject H_o: if $\chi^2_c > \chi^2_t$, Accept H_o: if $\chi^2_c < \chi^2_t$

Since $\chi^2_c > \chi^2_t$ i.e. 13.6146 > 9.49, we reject the null hypothesis and accept the alternative hypothesis that reduction of workers at-risk behaviours is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project. This is buttressed by the research findings of Grindle, Dickinson and Boettcher [29] who observed an increase in safe behaviours of workers after the consequent intervention/implementation of behavior-based safety programs in the activities of eighteen manufacturing organizations in the United States of America.

4.3.2 Test of the second hypothesis

I. **H_O:** Accident rate reduction is not dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.
II. **H_1:** Accident rate reduction is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project.
III. α =0.05.
IV. Degree of Freedom (df) = (r – 1)(c-1= (3-1)(3-1)=4.
V. (iv)Chi- square critical table value $(\chi^2_t) = \chi^2_{0.05} = 9.49$.

Table 6. Computation of Chi-square critical computed value (χ^2_c) from Table 4

Fo	Fe	(Fo-Fe)	(Fo-Fe)/Fe	$(Fo-Fe)^2/Fe$
9	6.95	2.05	0.2950	0.0870
1	2.89	-1.89	-0.6540	0.4277
1	1.16	-0.16	0.1379	0.0190
12	20.84	-8.84	-0.4242	0.1799
7	8.68	-1.68	-0.1935	0.0375
14	3.47	10.53	3.0346	9.2087
219	214.17	4.83	0.0226	0.0005
92	88.42	3.58	0.0405	0.0016
25	35.37	-10.37	-0.2932	0.0860
				χ^2_c=10.0479

(vi) **Decision Rule:** Reject $H_{o:}$ if $\chi^2_c > \chi^2_t$, Accept $H_{o:}$ if $\chi^2_c < \chi^2_t$

Since $\boldsymbol{\chi^2_c > \chi^2_t}$ i.e. 10.0479 > 9.49, we reject the null hypothesis and accept the alternative hypothesis that accident rate reduction is dependent on the implementation of behaviour-based safety programme in the Bonny NLNG construction project. This is buttressed by the research findings of Krause, Seymour, and Sloat [30] that examined the effects of behavior-based safety methods in 73 organizations and observed a significant decrease in incident rate with an average reduction of 26% in the first year and an average reduction of 69% by the end of the fifth year.

5. CONCLUSION AND RECOMMENDATIONS

This paper has tried to address employees' perception of the impact of behaviour-based safety on accident prevention in the Bonny NLNG construction project. Concisely stated it assumes that roughly 90% of all accidents, illnesses and injuries in the workplace are directly attributable to "man-failures" or the unsafe actions of workers hence setting up a system of well-planned antecedents and consequences can control the unsafe behaviors of employees thus reducing accidents and injuries in the workplace.

The main thrust of this paper is based on three principles: 1. At-risk behaviours/unsafe acts are fundamental to the occurrence of accidents.2. All behaviours arise from a combination of antecedents and consequences- antecedents serve as triggers to observable behaviours while consequences either enforce or discourage repetition of such behaviours. 3. A causal relationship exists between at-risk behaviours and the occurrence of workplace accidents and the latter can be prevented through the manipulation of the former using the Antecedent-Behaviour-Consequence (ABC) model.

The paper therefore recommends that all construction companies involved in the execution of the Bonny NLNG construction project should take the following measures to sustain the present safety record of reduced accident rate in their construction activities:

- A continuous review of employees' behaviour reinforcement techniques.
- Encouragement of workers to be their brother's keeper by observing and correcting each other's at-risk behaviours.
- Continuous commitment of management/workers to the elimination of at-risk behaviours in the workplace.
- Provision of extensive training for B-Safe observers.
- Training and re-training of workers/management team on safe work behaviours.
- Development of a list of "critical worker behaviours" often with input from workers.
- Development of 'model safe behaviours' so that workers' behaviours are measured against their own standards – i.e. past behaviours.
- A review of corporate safety policy, procedures and organizational system to support the behaviour-based safety programme to achieve its goal.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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