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Full Length Research

Effect of Behaviour-Based Safety Intervention in Pipeline Operation Sites in Nigeria

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The study investigated the effectiveness of Behavioral Based Safety (BBS) intervention amongst workers in pipeline construction and pipeline maintenance sites for the reduction in high injuries and accident frequency rate experienced at their locations. Multiple Correspondence Analysis was applied to check for similarity trend amongst pipeline workers with respect to safety management, actively caring and safety perception. Non-Linear regression functions were used to model from the BBS checklist, the percentage safe behaviour as related to the observed behavioral activity. Descriptive statistics was also used to analyze the BBS checklist within the baseline observation and intervention period. Within all groups of workers, it was shown (SP-Q7) that "Stress from factors outside work affects their ability to work safely". BBS process at site during baseline observation showed a baseline percentage of "risk behaviour" and "safe behaviour" to be significantly high in PPE (33%), Transportation (36%) and Body position (24%).It was also recorded at the third BBS intervention period, a reduction in the percentage of "risk behaviour", showing PPE (7%), Transportation (8%) and Body position (6%); after training, observation, coaching and feedback on critical behaviors were carried out. There was a remarkable improvement in the observation of Body position, Tool & Equipment and Transportation during the intervention period. It was also shown from the developed model the goodness of fit, R^2 of 61.3% was obtained with respect to risk at work activity.

Keywords: Behavior Based Safety (BBS), Safety Culture, Safe behavior, At-risk behavior.

INTRODUCTION

International concern and awareness of the importance and magnitude of occupational safety and health remains surprisingly modest. Alarming as the fatality, accident and disease figures are, investment, operational, and management decisions often continue to be made in disregard of safety and health considerations. In Nigeria at least 50 million are at risk of occupational hazards. This group includes about 3.2 million Nigerians and children who are involved in economic activities, even as abused participants in the labour market, while nothing less than 100 occupational fatalities and some billions of capital losses have been recorded in Nigeria between April 28, 2009 and April, 2010 (Fajana, 2011).

In the past, safety interventions were developed to improve safety performance (Krieger and Montgomery, 1997). Of these the most important was safety engineering, or safety design e.g.,

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equipment guards, emergency kill switches (Krieger and Montgomery, 1997). Another intervention of high importance was ergonomics. This intervention focuses on human beings and their interaction with products, equipment, procedures and environments (Sanders and McCormick, 1993). Other interventions that are worth mentioning include management audits, poster campaigns, near-miss reporting, root cause analysis, personnel selection problem solving techniques and safety systems design (Guastello, 1993). The development of a proper safety management system requires continual attention to three domains, namely the environment (equipment, tools, and house-keeping), the person, (knowledge, skills, abilities, intelligence, and personality) and behaviour (Geller, 1998a and 1998b). During last century much emphasis was placed on improving "the environment" and "the person" (Geller, 1996).

Reaching the performance plateau in safety performance, calls for introducing a next stage, namely the behavioural safety approach which introduces a planned schedule of events that combine to create an overall continuous improvement intervention (Krause, 1995). A behaviour based programme targets specific unsafe behaviour. The focus of the programme is on that small proportion of unsafe behaviour that is responsible for most of the company's accidents. The unsafe behaviour identified in the process is written onto a checklist in a system where employees observe each other. Behaviour based safety is based on observational data collection, on the basis of "what gets measured gets done". Safe and unsafe behaviour are fed into a system, so that behaviour can be monitored on a regular basis. The higher the number of observations, the more reliable the data. According to the Heisenberg Uncertainty Principle, the very act of observing and measuring people's safety behaviour alters the behaviour of those being observed (Cooper, 2000). This study is aimed at assessing the major drivers for implementation of a behaviour based safety intervention plan amongst pipeline workers in the Niger Delta region of Nigeria.

MATERIALS AND METHODS

Study Area

The Study area for the present study was the Niger Delta region of Nigeria. It comprises of 185 local government areas drawn from about nine (9) States (Rivers, Edo, Ondo, Delta, Cross Rivers, Bayelsa, Imo, Abia and Akwa Ibom) (UNDP, 2006). This region has a land-mass of 70 000 km^2 and it is the largest African wetland in the world (Oviasuyi and Uwadiae, 2010).

Major oil and gas exploration activities are carried out in this region within Nigeria, thus it houses major International Oil Companies (IOCs) and their facilities. The first area sampled, with respect to this study includes Pipeline maintenance on sectional replacement of gas pipeline at Ebocha, which is a populated place and is located in Rivers State, Nigeria. The estimated terrain elevation above sea level is 22 metres, Latitude: 5°27'43.56" and Longitude: 6°41'16.44. Second area sampled, was a Pipeline construction site for the Installation of gas flow line to a processing facility, located in an oil pipeline terminal South, Nigeria. The estimated terrain elevation above sea level is 7 metres, Latitude: 4°32'54.24" and Longitude: 8°0'45.72" (See Figure 1).

Data Collection

Procedure

The instrument employed for data collection was the BBS checklists, requiring the workers to either tick ‘safe’, or ‘at risk’ for each behavior type item listed. Baseline data were established with respect to respondents’ behavioral safety trend. This was to track their level of safe behavior or at-risk behavior over time.

Participants

The entire pipeline maintenance workers at Ebocha comprising of 40 Welders, 25 Fitters, 20 Scaffolders, 15 Riggers and Eket pipeline construction workers comprising of 50 Welders, 20 Fitters, 20 Scaffolders, 44 Riggers at project sites, were included in the analysis and not only one or some portions (sections).

The following activities were carried out by these workers: - Pipeline cleaning, pigging, pipe flushing, pipe descaling, valve servicing, hydro testing, intelligent pigging operations, Excavation, De-coating, welding and Fabrications operations, Installations and tie-in, Field joint coatings, Erection and Dismantling of scaffolds, and Site Restoration.

Figure 1. Map of Study Area, Niger Delta, Nigeria, Source: Google Map, 2017.

Checklist

The checklist administered with respect to this study was behavioural based. It consists of seven (7) segments and has a completion time of approximately 10 minutes. The segments include Body Positioning (BP); Tool and Equipment (T&E)), Work Area (WA), Work Procedure (WP), Personal Protective Equipment (PPE), Ergonomic and Body use (E&B), and Transportation (TRP). The checklists were of simple design, requiring the workers to either tick ‘safe’, or ‘at risk’ for each behavior type item listed. Those completing the peer-observation checklist on other workers’ actions were advised to ask for the reason the unsafe act had occurred, coach or reinforce if safe. Steering team members at the end of the work day collected completed checklists. These checklists were either placed into election type boxes scattered around the site, or handed back directly to the steering committee members, often via work group team leaders.

Questionnaire

The safety culture questionnaire was used for collecting responses from the subject selected for the study. It assessed different employees' perceptions and opinions regarding how strongly they believe them and others within the organization support safety, measures employee perceptions of many formal safety management systems and those instances of behavior which directly or indirectly impact on the safety of others.

It consisted of twenty-four (24) questions and has a completion time of approximately 10 minutes.

It was designed in a multiple choice format. Questions had statements in a five point Likert scale (always, often, sometimes, seldom and never).

Data Analysis

The statistical tools employed in data analyses were Principal Factor Analysis (PFA) and non-linear regression analysis embedded in XLSTAT 2016

computer software. The application of PFA is to identify the major intervention drivers among the respondents in terms of improvement in behavioural safety while the application of non-linear model was to develop an equation that fits the collected data defining the relationship between respondents' perception of at risk behavior and percentage safe behavoiural practices at the work place.

Principal Factor Analysis

Principal Factor Analysis (PFA) tends to characterize a set of observed variables x_1, x_2 …. x_n in terms of a number of "common" factors plus a factor which is exceptional to each variable. The common factors usually referred to as latent variables, are hypothetical variables which explain why a number of variables are correlated with each other because they tend to have one or more factors in common.

Given observed variables x_1, x_2 …. x_n, with common factors $F1$, $F2$ … Fm and unique factors U_1, U_2 …U_n, according to Taylor (2004), the observed variables may be expressed as linear functions of the factors (see Equation 1)

$$x_1 = a_{11}F1 + a_{12}F2 + a_{13}F3 + \ldots + a_{1m}Fm + a_1U_1$$
$$x_2 = a_{21}F1 + a_{22}F2 + a_{23}F3 + \ldots + a_{2m}Fm + a_2U_2$$
$$\ldots.$$
$$x_n = a_{n1}F1 + a_{n2}F2 + a_{n3}F3 + \ldots + a_{nm}Fm + a_nU_n \quad (1)$$

Factor analysis seeks to find the coefficients a_{11}, a_{12} … a_{nm} which best reproduce the observed variables from the factors.

Non-linear Regression Analysis

According to Taylor (2016), many real-life phenomena can be parameterized by *non-linear* regression functions, examples include radioactive decay models. The governing equation employed for model development with regards to the data collected using the checklist is as presented by Equation (2). This is to model the percentage safety against observed behavioral work related activity that was at risk.

Function: $y = c_1 + c_2x + c_3x^2 + c_4x^3 + c_5x^4$ (2)

Where y = Relative % safe

x = at Risk; c = constant, and c_1, c_2, c_3, . . …are coefficients

RESULTS

On application of principal factor analysis on the collected data Figures 2(a and b) and 3 present the asymmetric plots of the observed Questionnaire parameters against responses from respondents form Eket and Ebotcha, respectively. Tables 1 and 2 present the squared cosines of the observation reflecting the resultant factors. Furthermore, Figures 4 – 7 present plots of percentage risk of workers from observation and checklist analysis (see Appendix A). Finally, Table 3 presents the goodness of fit statistic of the resultant non-linear model fitting the collected data with respect to the percentage safety as related to the observed behavioural work related at risk activities by the respondents (see Figure 7).

DISCUSSION

In Eket pipeline construction site within all groups of workers Multiple Correspondence Analysis showed SP-Q7 that "Stress from factors outside my work affects my ability to work safely". This was similarly recorded for Ebocha pipeline maintenance site among workers. In Ebocha pipeline construction site, within all groups of workers showed, AC-Q7 "I approach my co-workers about their unsafe behaviour, they will react negatively". Workers also showed actively caring (AC-Q1). "I feel pressure from my co-workers to 'short cut' on safety practice". (SM-Q1) "My supervisor is well informed about important safety issues".

The Behavioural Based Safety process at Eket pipeline construction site was carried out using the checklist (Body position, Tool and Equipment, Work area, Procedure, Personal Protective Equipment (PPE), Ergonomics, Transportation), as it showed a baseline percentage of "risk behaviour" and "safe behaviour" within the period of baseline observation, (Figure 3) to be significantly high in PPE (33%), Transportation (36%) and Body position (24%). It was also recorded at the third BBS intervention quarter (Figure 3), a reduction in the percentage of "risk behaviour showing PPE (7%), Transportation (8%) and Body position (6%), after training, observation, coaching and feedback on critical behavior were carried out. Subsequently, the percentage safe (Figure 4) in the last intervention quarter shows; Body position (32%), Tool & Equipment (38%), PPE (27%),Transportation (28%).

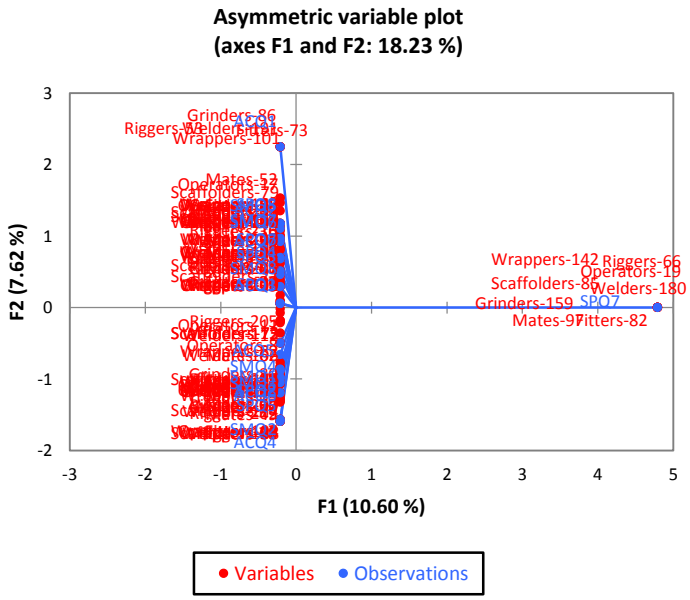

Figure 2a. PFA output with respect to respondents from Eket.

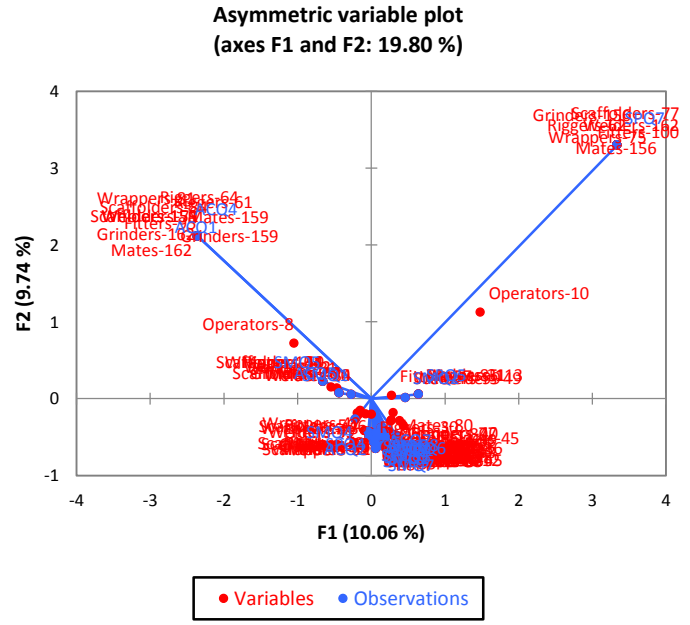

Figure 2b. PFA output with respect to respondents from Ebocha.

This implies a remarkable improvement in Body position, Tool & Equipment and Transportation given the quarterly intervention period.

It was observed that Tool & Equipment were

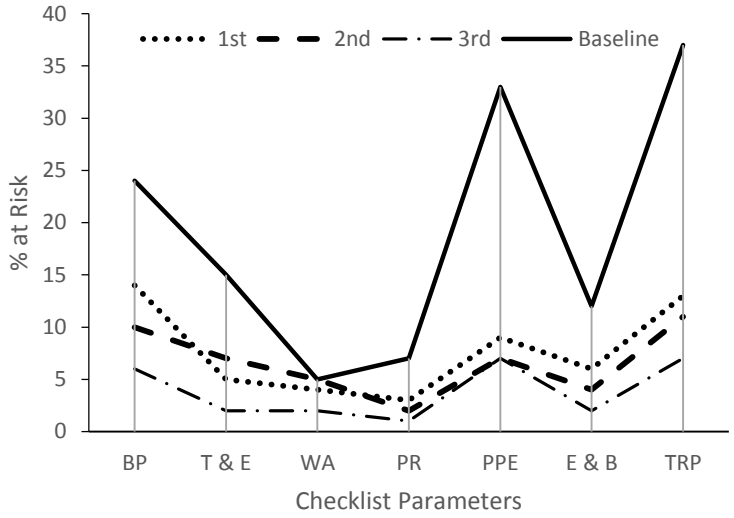

Figure 3. Plot of Summary of Percentage at- risk for Workers in Eket (before intervention).

inspected daily and maintained at site. Work area was clean and tidy; as house-keeping was carried out daily and after close of task. Procedures (HSE Plan, Job Hazards Analysis JHA, confined space, work at height, lifting plan,) were developed and hot work permits signed daily. This explains the low "percentage risk" and high percentage safe observed (Figures 3 and 4). Manual handling techniques regarding body position were not observed. Drivers on site did not possess a valid defensive driving course certificate; as there was not journey management process in place.

Ebocha pipeline maintenance site BBS process also adopted the use of the BBS checklist (Body position, Tool and Equipment, Work area, Procedure, PPE, Ergonomics, and Transportation). Baseline percentage of "risk behaviour" within the observation period (Figure 5) showed to be significantly high in Body position (20%), PPE (36%) and Transportation (30%). BBS Baseline 1st Quarter (Figure 5), percentage of "safe behaviour shows Body position (11%), PPE (12%), Transportation (9%). Subsequently, the percentage safe (Figure 6) in the last intervention quarter shows an increase in percentage of Body position (28%), PPE (25%), Transportation (28%). This implies a remarkable improvement in Body position, Tool & Equipment and Transportation given the intervention period (Figure 6).

Similar study was carried by Mettert (2006) on "The Effectiveness of the Behaviour-Based Safety Program at Jacobs Sverdrup's NASA Langley Rome Contract". The study was to determine if the implementation of the behaviour-based safety program at the ROME contract NASA Langley Research Center lowered the amount of safety incidents. The findings of the study suggest the implementation of the behavior-based safety program lowered the number of safety incidents. Comparatively, Geller and Williams (2001) carried out a study on "Behavior-Based Intervention for Occupational Safety: Critical Impact of Social Comparison Feedback, SCF". Study showed that, Behavior-based feedback increased percent safe scores from baseline to intervention, and these improvements were maintained for three of four groups after the BB feedback intervention was withdrawn. Global/SCF provided the most promising results in terms of cost effectiveness, and Global/No. of SCF was least effective.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the results of this study, the following conclusion can be drawn;

1) The findings of this study suggest the implementation of the behaviour-based safety program lowered the number of recordable safety

Table 1. Squared cosines (Observations at Eket).

±QP	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
SMQ1	0.0033	0.0501	0.0505	0.0019	0.0005	0.0224	0.1628	0.1521	0.0862	0.0243	0.0006	0.0221	0.0122	0.0563	0.0003
SMQ2	0.0030	0.1470	0.0105	0.0026	0.0967	0.0002	0.0000	0.1780	0.0001	0.0759	0.0146	0.0230	0.0628	0.0015	0.1980
SMQ3	0.0033	0.0517	0.0359	0.0000	0.0109	0.0262	0.0765	0.0602	0.0178	0.0668	0.0000	0.1722	0.0080	0.0911	0.0022
SMQ4	0.0048	0.0420	0.0154	0.0282	0.1044	0.0011	0.0165	0.0465	0.0235	0.0030	0.0047	0.0316	0.0448	0.0297	0.0848
SMQ5	0.0031	0.0844	0.0906	0.0001	0.0131	0.0004	0.0590	0.0503	0.0961	0.0087	0.2242	0.0426	0.0038	0.0011	0.0774
SMQ6	0.0026	0.0433	0.0842	0.1212	0.1004	0.0862	0.1677	0.1209	0.0191	0.0039	0.1221	0.0200	0.0065	0.0492	0.0029
SMQ7	0.0027	0.0495	0.0154	0.0033	0.1018	0.3171	0.0663	0.0534	0.0229	0.0175	0.0005	0.2341	0.0240	0.0045	0.0368
SMQ8	0.0030	0.0049	0.2314	0.0016	0.0084	0.0001	0.0011	0.0230	0.0699	0.0735	0.0036	0.0617	0.2216	0.0613	0.0288
ACQ1	0.0024	0.2423	0.0002	0.3193	0.1130	0.0982	0.0041	0.0180	0.0404	0.0187	0.0802	0.0240	0.0000	0.0072	0.0100
ACQ2	0.0028	0.0668	0.0371	0.1896	0.0503	0.0000	0.0180	0.0188	0.0009	0.0285	0.2728	0.0427	0.0255	0.0167	0.0000
ACQ3	0.0026	0.0001	0.3718	0.0339	0.0067	0.0012	0.1054	0.1555	0.0222	0.0057	0.0352	0.0358	0.2014	0.0003	0.0062
ACQ4	0.0024	0.1246	0.0143	0.0636	0.3247	0.2515	0.1468	0.0025	0.0005	0.0020	0.0183	0.0026	0.0105	0.0102	0.0006
ACQ5	0.0032	0.0158	0.0021	0.0874	0.0211	0.0089	0.0499	0.0032	0.0776	0.0058	0.0227	0.0891	0.1104	0.1799	0.0394
ACQ6	0.0042	0.0940	0.0226	0.0032	0.0062	0.0206	0.0217	0.0002	0.0428	0.0003	0.0439	0.0001	0.0036	0.0273	0.0216
ACQ7	0.0029	0.0270	0.0193	0.1691	0.0080	0.0810	0.0086	0.0023	0.1808	0.0057	0.0000	0.0351	0.0195	0.0151	0.1777
ACQ8	0.0034	0.0676	0.0069	0.0032	0.0781	0.0142	0.0329	0.1556	0.0247	0.0872	0.0104	0.0377	0.0216	0.0117	0.1855
SPQ1	0.0035	0.0002	0.0108	0.0077	0.0696	0.0025	0.0306	0.0003	0.0071	0.0249	0.1000	0.0221	0.0032	0.0405	0.0044
SPQ2	0.0033	0.0633	0.0017	0.0235	0.0001	0.0820	0.1016	0.0329	0.0215	0.0703	0.0053	0.0330	0.0080	0.1123	0.0907
SPQ3	0.0035	0.0146	0.0665	0.0075	0.0001	0.0452	0.0551	0.0010	0.0082	0.0241	0.0112	0.0059	0.0726	0.2065	0.0307
SPQ4	0.0026	0.0135	0.1146	0.1223	0.0445	0.0454	0.0045	0.0989	0.2759	0.1261	0.0010	0.0301	0.0000	0.0152	0.0005
SPQ5	0.0028	0.0799	0.0344	0.0069	0.0647	0.0358	0.0318	0.0335	0.0656	0.3806	0.0010	0.0012	0.0968	0.0589	0.0132
SPQ6	0.0031	0.0295	0.0081	0.0512	0.0122	0.0199	0.0008	0.0045	0.0695	0.0604	0.0764	0.0984	0.0590	0.0490	0.0001
SPQ7	**1.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPQ8	0.0035	0.0957	0.1015	0.0051	0.0102	0.0024	0.0880	0.0001	0.0181	0.0255	0.0573	0.0305	0.0063	0.0005	0.0094

±QP = Questionnaire Parameter, i.e SMQ1 = Safety Management Question 1; ACQ1 = Active Care Question 1; SPQ1 = Safety Perception Question 1.

incidents in the pipeline industry sites.

2) Behavior-based feedback increased percentage safe scores from baseline to intervention, and these improvements were maintained for the various groups of pipeline workers at the various sites.

3) Stress related issues outside work, affects the productivity of pipeline workers. Fear of reporting unsafe act and condition, due to blame game and likely punitive measures.

4) The Behavioural Based Safety

Table 2. Squared cosines (Observations at Ebocha).

±QP	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
SMQ1	0.0062	0.0002	0.0027	0.0179	0.0618	0.0790	0.0212	0.0098	0.0017	0.0067	0.0005	0.0000	0.0676	0.0741	0.0122
SMQ2	0.0192	0.0000	0.0133	0.0038	0.0242	0.0001	0.1222	0.0000	0.0218	0.0020	0.0068	0.0000	0.1148	0.0142	0.0425
SMQ3	0.0002	0.0239	0.0003	0.3660	0.0312	0.0527	0.0187	0.0449	0.4366	0.0001	0.0112	0.0000	0.0011	0.0010	0.0025
SMQ4	0.0046	0.0070	0.0214	0.0762	0.0739	0.0196	0.0032	0.0023	0.0509	0.0154	0.0083	0.0000	0.0031	0.0024	0.0415
SMQ5	0.0257	0.0030	0.0754	0.1221	0.1866	0.1501	0.0009	0.1628	0.0225	0.0247	0.0006	0.0000	0.0218	0.0862	0.0186
SMQ6	0.0004	0.0237	0.0617	0.0668	0.0083	0.0848	0.0955	0.0950	0.0008	0.1353	0.0606	0.0000	0.0000	0.0184	0.0779
SMQ7	0.0062	0.0213	0.4100	0.1220	0.0029	0.0539	0.0789	0.1795	0.0017	0.0104	0.0197	0.0000	0.0499	0.0032	0.0148
SMQ8	0.0023	0.0129	0.0000	0.0002	0.0044	0.0040	0.1926	0.0039	0.0204	0.1399	0.0103	0.0000	0.2378	0.0003	0.2397
ACQ1	0.2951	0.2345	0.0085	0.0036	0.0188	0.0080	0.0005	0.0012	0.0000	0.0002	0.0001	0.4286	0.0001	0.0001	0.0001
ACQ2	0.0000	0.0144	0.1763	0.0566	0.0059	0.2790	0.1665	0.0294	0.0006	0.0589	0.0165	0.0000	0.0551	0.0231	0.0000
ACQ3	0.0004	0.0180	0.0819	0.0028	0.0867	0.0111	0.0442	0.0454	0.0236	0.1714	0.2577	0.0000	0.0129	0.0023	0.0049
ACQ4	0.2951	0.2345	0.0085	0.0036	0.0188	0.0080	0.0005	0.0012	0.0000	0.0002	0.0001	0.4286	0.0001	0.0001	0.0001
ACQ5	0.0128	0.0004	0.0363	0.0419	0.0815	0.0283	0.0426	0.0144	0.0009	0.0003	0.0275	0.0000	0.0106	0.5388	0.0024
ACQ6	0.0077	0.0151	0.1165	0.0712	0.0311	0.0003	0.0534	0.0637	0.0594	0.0478	0.0000	0.0000	0.0529	0.0025	0.0236
ACQ7	0.0016	0.0127	0.0068	0.0014	0.0006	0.0440	0.1505	0.0099	0.0248	0.1049	0.0063	0.0000	0.0020	0.0225	0.0002
ACQ8	0.0016	0.0224	0.0086	0.0085	0.0583	0.0265	0.0236	0.0020	0.0131	0.1108	0.1615	0.0000	0.0016	0.0285	0.0083
SPQ1	0.0027	0.0169	0.0760	0.0050	0.1290	0.0481	0.0334	0.0544	0.0480	0.1160	0.0451	0.0000	0.1039	0.0041	0.0384
SPQ2	0.0012	0.0217	0.0164	0.0899	0.2220	0.1614	0.0547	0.0227	0.0355	0.0000	0.3450	0.0000	0.0034	0.0033	0.0009
SPQ3	0.0003	0.0153	0.0600	0.0193	0.0000	0.0388	0.0350	0.0662	0.0099	0.0196	0.0325	0.0000	0.0035	0.1327	0.0662
SPQ4	0.0001	0.0119	0.0068	0.0142	0.1226	0.0106	0.0093	0.1327	0.0266	0.1605	0.0162	0.0000	0.2235	0.0315	0.0936
SPQ5	0.0298	0.0002	0.0321	0.0738	0.0164	0.0002	0.0968	0.0682	0.0236	0.0017	0.0321	0.0000	0.0002	0.0794	0.1894
SPQ6	0.0014	0.0190	0.0398	0.0018	0.0041	0.0847	0.0156	0.1137	0.0147	0.0252	0.0189	0.0000	0.0005	0.0025	0.0101
SPQ7	0.4936	0.4758	0.0009	0.0056	0.0030	0.0000	0.0100	0.0014	0.0000	0.0000	0.0001	0.0000	0.0012	0.0015	0.0033
SPQ8	0.0001	0.0206	0.0916	0.0745	0.1074	0.0255	0.0002	0.0419	0.2584	0.0053	0.0246	0.0000	0.1055	0.0033	0.1161

±QP = Questionnaire Parameter, i.e SMQ1 = Safety Management Question 1; ACQ1 = Active Care Question 1; SPQ1 = Safety Perception Question 1.

process at Eketpipeline construction site, showed a baseline percentage of "risk behaviour" and "safe behaviour" during baseline observation, to be significantly high in PPE (33%), Transportation (36%) and Body position (24%).

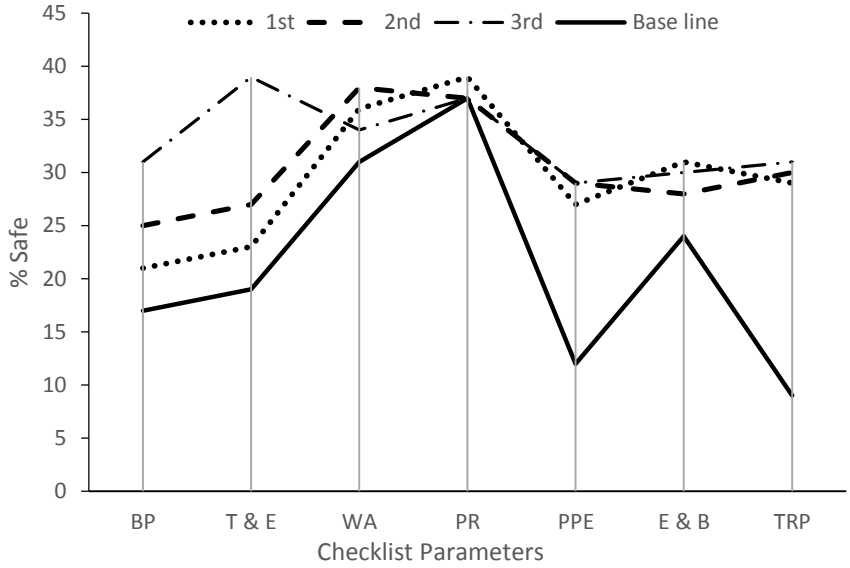

Figure 4. Plot of Summary of Percentage Safe for workers in Eket (intervention).

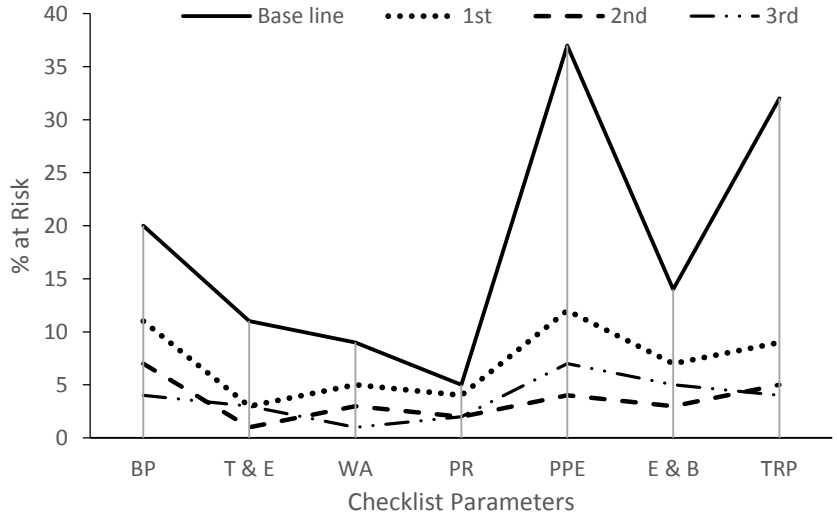

Figure 5. Plot of Summary of Percentage at-Risk for Workers in Ebocha (before intervention).

It was also recorded at the final BBS intervention quarter, a reduction in the percentage of "risk behaviour showing PPE (7%), Transportation (8%) and Body position (6%), after training, observation, coaching and feedback on critical behavior.

5) It was observed that Tool & Equipment were inspected daily and maintained at site. Work area was clean and tidy; as house-keeping was carried out daily and after close of task. Procedures (HSE plan, Job Hazards Analysis JHA, confined space,

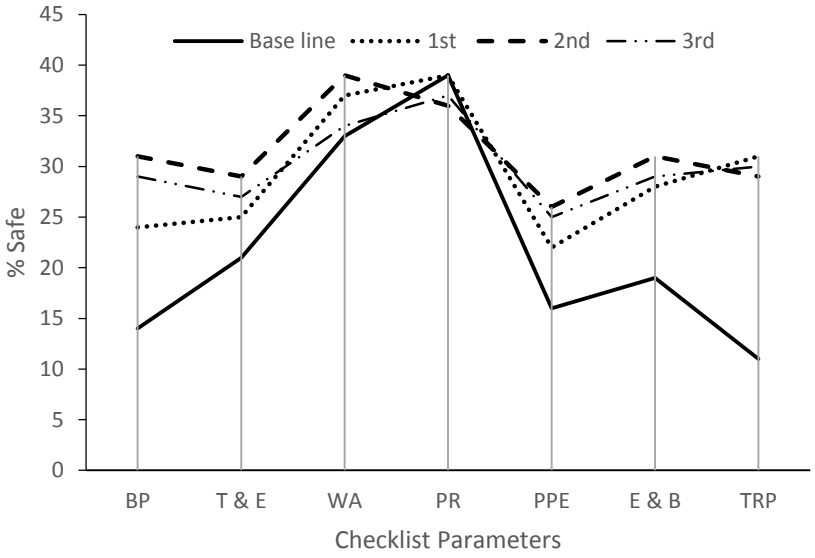

Figure 6. Plot of Summary of Percentage Safe for workers in Ebocha (Intervention).

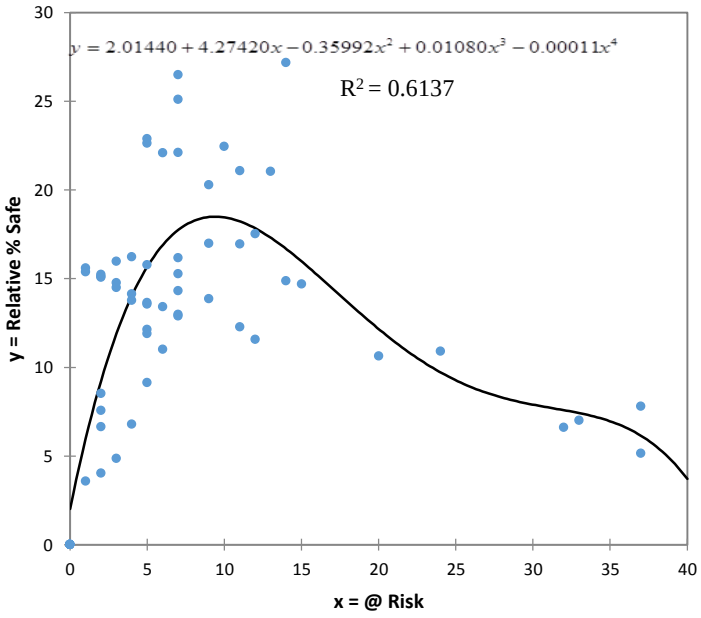

Figure 7. Plot of non-linear regression model of Relative percentage safe versus at risk behavioral work activities.

work at height, lifting plan,) were developed and hot work permits signed daily. This explains the low "percentage risk" and high percentage safe observed in these items.

6) Ebocha pipeline maintenance site BBS process has significantly high risk in Body position (20%), PPE (36%) and Transportation (30%).

7) Subsequently the percentage safe (Figure

Table 3. Goodness of fit statistic.

Observations	64.0000
DF	59.0000
R^2	0.6137
SSE	1233.5538
MSE	20.9077
RMSE	4.5725

6) in the last intervention quarter shows an increase in percentage of Body position (28%), PPE (25%), Transportation (28%). This implies a remarkable improvement in Body position, Tool & Equipment and Transportation given the intervention period.

Recommendation

1) For a more proactive safety culture, a behavioral based safety program can be maintained; by peer to peer observation of workers safe and at-risk behavior; coaching and giving feedback, thereby gaining trust and improving on the safety culture and performance.

2) Journey management system should be established, as road traffic accident accounts for recordable accident statistics at work.

3) Allocation of resources, as regards provision of personal protective equipment (PPEs) and specialized PPE's to pipeline workers at no cost, on site is mandatory. Unavailability of personal protective equipment, poses a risk to injury; leading to the high percentage of risk behaviour recorded at various sites.

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APPENDIX A: CHECKLIST ANALYSES

Table A1. Baseline data for Pipeline workers at Eket.

CODE	BEHAVIOUR TYPES	SAFE	AT RISK
1	**BODY POSITION**		
1.1	Line of Fire	3	5
1.2	Eyes on Path	5	3
1.3	Eyes on Task	3	6
1.4	Pinch out	4	5
1.5	Ascending / Descending	2	5
	Total	**17**	**24**
2	**TOOLS AND EQUIPMENT**		
2.1	Selection and Condition	6	3
2.2	Use	5	4
2.3	Guards, Barricade / Warning Devices	8	8
	Total	**19**	**15**
3	**WORK AREA**		
3.1	Walking / Working Surface	13	1
3.2	House Keeping	10	1
3.3	Spill Prevention / Managing Waste	8	3
	Total	**31**	**5**
4	**PROCEDURES**		
4.1	Job safety Analysis	6	2
4.2	Lock out Tag Out	8	1
4.3	Permit to Work	7	2
4.4	Security Procedure	9	1
4.5	Communication	7	1
	Total	**37**	**7**
5	**PERSONAL PROTECTIVE EQUIPMENT (PPE)**		
5.1	Head	3	5
5.2	Eyes, Face and Hearing	2	6
5.3	Respiration	1	6
5.4	Hands and Arms	2	5
5.5	Clothing / Fall Protection / PFD	2	7
5.6	Feet Protection	2	4
	Total	**12**	**33**
6	**ERGONOMICS AND BODY USE**		
6.1	Lifting, Lowering, Pushing, Pulling	7	3
6.2	Over Reaching / Twisting	4	4
6.3	Repetitive Motion / Rest Breaks	7	3
6.4	Body Posture	6	2
	Total	**24**	**12**
7	**TRANSPORTATION (DRIVING / MARINE)**		

Table A1. Contd..

7.1	Journey Planning and Pre-trip Inspection	4	12
7.2	Speed / Vision and Scanning	3	6
7.3	Breaking / Reversing / Parking	1	9
7.4	Seat Belt	1	10
	Total	**9**	**37**

Table A2. Baseline data for Pipeline workers at Ebocha.

CODE	BEHAVIOUR TYPES	SAFE	AT RISK
1	**BODY POSITION**		
1.1	Line of Fire	3	4
1.2	Eyes on Path	4	2
1.3	Eyes on Task	2	5
1.4	Pinch out	3	4
1.5	Ascending / Descending	2	5
	Total	**14**	**20**
2	**TOOLS AND EQUIPMENT**		
2.1	Selection and Condition	6	4
2.2	Use	6	4
2.3	Guards, Barricade / Warning Devices	9	3
	Total	**21**	**11**
3	**WORK AREA**		
3.1	Walking / Working Surface	13	2
3.2	House Keeping	11	4
3.3	Spill Prevention / Managing Waste	9	3
	Total	**33**	**9**
4	**PROCEDURES**		
4.1	Job safety Analysis	7	1
4.2	Lock out Tag Out	8	1
4.3	Permit to Work	7	2
4.4	Security Procedure	9	0
4.5	Communication	8	1
	Total	**39**	**5**
5	**PERSONAL PROTECTIVE EQUIPMENT (PPE)**		
5.1	Head	4	5
5.2	Eyes, Face and Hearing	2	6
5.3	Respiration	2	6
5.4	Hands and Arms	3	5
5.5	Clothing / Fall Protection / PFD	3	7
5.6	Feet Protection	2	8

Table A2. Contd..

	Total	**16**	**37**
6	**ERGONOMICS AND BODY USE**		
6.1	Lifting, Lowering, Pushing, Pulling	5	3
6.2	Over Reaching / Twisting	4	5
6.3	Repetitive Motion / Rest Breaks	6	3
6.4	Body Posture	4	3
	Total	**19**	**14**
7	**TRANSPORTATION (DRIVING / MARINE)**		
7.1	Journey Planning and Pre-trip Inspection	4	8
7.2	Speed / Vision and Scanning	3	6
7.3	Breaking / Reversing / Parking	2	9
7.4	Seat Belt	2	9
	Total	**11**	**32**

Table A3i. Checklist data of Pipeline workers at intervention in Eket.

		1st Quarter			2rd Quarter			3rd Quarter	
CODE	**BEHAVIOUR TYPES**	**SAFE**	**AT RISK**		**SAFE**	**AT RISK**		**SAFE**	**AT RISK**
1	**BODY POSITION**								
1.1	Line of Fire	4	3		5	1		6	1
1.2	Eyes on Path	5	2		4	5		7	1
1.3	Eyes on Task	6	1		6	1		6	1
1.4	Pinch out	3	4		5	2		7	1
1.5	Ascending / Descending	3	4		5	1		5	2
	Total	**21**	**14**		**25**	**10**		**31**	**6**
2	**TOOLS AND EQUIPMENT**								
2.1	Selection and Condition	9	2		9	3		10	1
2.2	Use	6	1		9	2		16	0
2.3	Guards, Barricade / Warning Devices	8	2		9	2		13	1
	Total	**23**	**5**		**27**	**7**		**39**	**2**
3	**WORK AREA**								
3.1	Walking / Working Surface	10	1		11	3		11	0
3.2	House Keeping	10	2		12	1		9	1
3.3	Spill Prevention / Managing Waste	16	1		15	1		14	1
	Total	**36**	**4**		**38**	**5**		**34**	**2**
4	**PROCEDURES**								
4.1	Job safety Analysis	7	0		8	1		9	0
4.2	Lock out Tag Out	5	1		7	0		7	0
4.3	Permit to Work	10	0		9	0		8	0
4.4	Security Procedure	9	1		7	0		7	0

Table A3i. Contd..

4.5	Communication	8	1		6	1		6	1
	Total	**39**	**3**		**37**	**2**		**37**	**1**
5	**PERSONAL PROTECTIVE EQUIPMENT (PPE)**								
5.1	Head	5	2		6	0		5	1
5.2	Eyes, Face and Hearing	3	1		3	2		4	2
5.3	Respiration	4	1		6	1		5	1
5.4	Hands and Arms	5	2		5	1		4	2
5.5	Clothing / Fall Protection / PFD	4	2		4	2		6	0
5.6	Feet Protection	6	1		5	1		5	1
	Total	**27**	**9**		**29**	**7**		**29**	**7**
6	**ERGONOMICS AND BODY USE**								
6.1	Lifting, Lowering, Pushing, Pulling	9	1		8	1		10	0
6.2	Over Reaching / Twisting	6	2		7	1		7	1
6.3	Repetitive Motion / Rest Breaks	7	2		6	1		6	1
6.4	Body Posture	9	1		7	1		7	0
	Total	**31**	**6**		**28**	**4**		**30**	**2**
7	**TRANSPORTATION (DRIVING / MARINE)**								
7.1	Journey Planning and Pre-trip Inspection	7	2		6	4		7	2
7.2	Speed / Vision and Scanning	8	4		7	3		7	2
7.3	Breaking / Reversing / Parking	5	6		8	3		9	1
7.4	Seat Belt	9	1		9	1		8	2
	Total	**29**	**13**		**30**	**11**		**31**	**7**

Table A3ii. Checklist data of Pipeline workers at intervention in Ebocha.

		1st Quarter			2rd Quarter			3rd Quarter	
CODE	**BEHAVIOUR TYPES**	**SAFE**	**AT RISK**		**SAFE**	**AT RISK**		**SAFE**	**AT RISK**
1	**BODY POSITION**								
1.1	Line of Fire	4	3		6	1		6	1
1.2	Eyes on Path	5	1		5	2		7	0
1.3	Eyes on Task	7	1		6	1		5	1
1.4	Pinch out	5	3		8	1		6	0
1.5	Ascending / Descending	3	3		6	2		5	2
	Total	**24**	**11**		**31**	**7**		**29**	**4**

Table A3ii. Contd..

2	**TOOLS AND EQUIPMENT**								
2.1	Selection and Condition	10	1		10	0		9	1
2.2	Use	7	1		9	1		9	1
2.3	Guards, Barricade / Warning Devices	8	1		10	0		9	1
	Total	**25**	**3**		**29**	**1**		**27**	**3**
3	**WORK AREA**								
3.1	Walking / Working Surface	10	1		12	1		12	0
3.2	House Keeping	11	2		12	1		9	1
3.3	Spill Prevention / Managing Waste	16	2		15	1		13	0
	Total	**37**	**5**		**39**	**3**		**34**	**1**
4	**PROCEDURES**								
4.1	Job safety Analysis	7	1		8	0		9	0
4.2	Lock out Tag Out	5	1		7	1		7	1
4.3	Permit to Work	10	0		8	0		8	0
4.4	Security Procedure	9	1		7	0		7	0
4.5	Communication	8	1		6	1		6	1
	Total	**39**	**4**		**36**	**2**		**37**	**2**
5	**PERSONAL PROTECTIVE EQUIPMENT (PPE)**								
5.1	Head	4	2		5	0		5	0
5.2	Eyes, Face and Hearing	3	2		3	2		3	2
5.3	Respiration	3	3		5	0		4	2
5.4	Hands and Arms	3	3		4	1		4	1
5.5	Clothing / Fall Protection / PFD	4	1		4	1		5	0
5.6	Feet Protection	5	1		5	0		4	2
	Total	**22**	**12**		**26**	**4**		**25**	**7**
6	**ERGONOMICS AND BODY USE**								
6.1	Lifting, Lowering, Pushing, Pulling	8	1		8	1		9	0
6.2	Over Reaching / Twisting	6	3		8	0		7	1
6.3	Repetitive Motion / Rest Breaks	6	2		7	1		6	3
6.4	Body Posture	8	1		8	1		7	1
	Total	**28**	**7**		**31**	**3**		**29**	**5**

Table A3ii. Contd..

7	**TRANSPORTATION (DRIVING / MARINE)**								
7.1	Journey Planning and Pre-trip Inspection	9	1		6	2		7	1
7.2	Speed / Vision and Scanning	8	3		7	1		6	2
7.3	Breaking / Reversing / Parking	5	4		7	1		9	0
7.4	Seat Belt	9	1		9	1		8	1
	Total	**31**	**9**		**29**	**5**		**30**	**4**