ID 060

ASSESSING THE SAFETY CLIMATE IN GHANA'S UPSTREAM OIL AND GAS SECTOR

F. Horbah, C. Pathirage and U. Kulatunga

School of the Built Environment, University of Salford, Salford, M5 4WT, UK

Email: f.horbah@edu.salford.ac.uk

Abstract: Oil and Gas industry reported that the industry has highly hazardous environments, with multiple technological, human and environmental challenges which have potentially severe consequences to workers' lives, asserts loss, environmental pollutions and disruption of security of energy supply. The use of safety climate measures to assess safety performance in an organisation is considered as a proactive or predictive approach to safety management. There are insufficient empirical studies on the establishment of current safety performance in Ghana's upstream oil and gas operations. This paper seeks to assess the current safety climate predictive influences on major accident risks in Ghana's upstream oil and gas sector. Safety climate survey questionnaires made up of 60 items in 14 constructs were used to assess the current employees' safety perceptions. 212 responses from upstream oil and gas workers were received and analyzed. The results show that safety priority and supportive environment were found to have high predictive influence on major accident risks. In addition, safety supervision, management of change, equipment maintenance and management commitment indicate predictive influence on major accident risks. The findings of this study provide valuable guidance for researchers and industrial practioners to identify mechanisms by which they can improve existing safety at the work environment.

Keywords: safety climate, safety indicator, safety management, safety performance, upstream oil and gas operations.

1. INTRODUCTION

There have been many researches indicating an increasing trend of industrial work- related injuries, fatalities and asserts losses at the various workplaces in Ghana (e.g. Ayarkwa et al., 2010; Norman et al., 2015; Bayire, 2016). The economic cost of industrial accidents in the country is estimated to be $16 million annually (Norman et al. 2015). Ghana's oil and gas industry is one of these industries recently experiencing work-related fatalities, injuries and asserts loss (Ocloo, 2017; Tetteh, 2017). Studies (e.g. Amorin 2013; Hystad et al. 2014) have found that workers in this safety critical industry operate in highly hazardous environments, with multiple technological, human and environmental challenges which have potential severe consequences to workers' lives, asserts loss and environmental pollutions.

Safety climate is the shared perceptions of the employees on safety policies, procedures and practices at the work environment (Zohar, 2003; Brondino et al., 2012). Safety climate has been found as a robust predictor of organisational safety performance (Cooper & Phillips, 2004; Andreas et al., 2016; Griffin & Curcuruto, 2016; Huang et al. 2017). However, there are limited studies that have investigated the relationship between safety climate and major accident in the oil and gas industry. Existing studies are characterised with poor investigation of such relationship. There is confusion between the terms 'conditions' and 'causes' of accident in the literature. It can be argued that safety climate best measures conditions (indirect indicators) contributing to accidents and not causes (direct indicators) of accident.

Safety climate serves as a leading indicator for major accident risk. There are limited empirical studies on prevailing conditions that could contribute to major accident risks in Ghana’s upstream oil and gas sector.

The purpose of this paper is to assess the current safety climate constructs that could predict major accidents risks in Ghana’s upstream oil and gas sector. Ghana’s upstream oil and gas sector (exploration and production sector) strategically contributes to the country’s energy needs and assert of high value to its local economy. There is the need to know and understand the prevailing human and organisational conditions that could provide ‘early warning’ of potential safety system failures in the industry. Exposing these conditions would help managers to put corrective measures in place to avoid possible future major incidents in the Ghana oil and gas industry. Overall, this study contributes to the development of safety climate as a leading major accident risk indicator.

The paper is organised as follows: the next section reviews safety climate as a leading major safety indicator; the third section presents the methodology of the study, the fourth section presents the results and analysis of the study, and finally concludes in the fifth section.

2. SAFETY CLIMATE AND MAJOR ACCIDENTS IN THE OIL AND GAS INDUSTRY

Most major accident investigative reports in the oil and gas industry (e.g. Cullen, 1990; Baker, 2007; CSB, 2014) and scientific studies on analysis of hydrocarbon leaks (e.g. Sklet, 2006; 2010; Vinnem et al, 2007a; Okstad et al. 2009; Haugen et al, 2010) have indicated that human and organisational factors are the main important causal factors. Various studies have established that culture is the main driver and predictor of shaping organisational safety performance (Flin et al., 2000). However, given the conceptual challenges of measuring safety culture (Guldenmund, 2000; 2007; Glenton & Stantan, 2000), most studies have used the term safety climate to describe the tangible outputs or indicators of an organization’s safety culture. Safety climate’ has been established in the literature as an indicator that predicts organisational safety performance. However, many of the existing safety climate assessment relating to the high-risk industries focus on personal safety indicators which have limited scope to capture proactive indicators of major accident risk factors.

2.1 Organizational Climate

Organisational climate is defined as the workers’ perception of work environment events and the expectations that the organisation has of workplace behaviour, attitudes, and norms (Ostroff et al., 2003). According to Schneider (1990), organisation climate is made up of shared perceptions among employees regarding the procedures, practices and the kind of behaviour that is rewarded and supported relating to the specific environment in question. From these definitions, the key attribute of organisational climate is the *shared* employees’ perceptions regarding the work environment. Zohar (2000) argues that this attribute emerges as a group-level property which actually develops from individual members’ experiences and perceptions of the work environment and progressively become *socially shared*. According to Schneider (1975), organisational climate arises through individual perceptions of order in the workplace and also through the creation of new order by inferring from what is perceived. It is a multidimensional construct that is made up of individual evaluation of the work environment. Organisational climate provides the context in which specific individual evaluation of the value of safety are made (Neal et al., 2000). This implies that organisational climate can predict specific safety climate.

2.2 Safety Climate

The original paper defines safety climate as "shared employee perceptions about the relative importance of safe conduct in their occupational behavior" (Zohar, 1980: p.96). Other researchers view it as a specific facet of social climate in organizations regarding perceptions of the priority of policies, procedures and practices relating to safety (Flin et al., 2000; Zohar, 2000; Zohar and Luria, 2005). Payne et al. (2010) defines *policies* as "the organizational goals and means for goal attainment, while *procedures* provide tactical guidelines for actions relating to these goals". And *practices* refer to the "implementation of policies and procedures by managers within each workgroup" (p.806). From these definitions of safety climate, the term safety climate is identified as mainly social consensual or shared social cognition.

The number of scientific studies on safety climate has been progressing over the last 30 years. In recent times, safety climate is found as a robust indicator of both subjective and objective organisational safety performance (Bosak et al. 2013; Andreas et al., 2016; Huang et al., 2017). There have been much focus on methodological issues rather than its theoretical or conceptual issues (see e.g. Høivik et al. 2009; Bosak et al., 2013; Mihajlovic, 2013; Dahl & Olsen, 2013; Hystad et al., 2014; Rémi et al., 2015; Kvalheim & Dahl, 2016; Bayire, 2016). However, there are conceptual ambiguities in the safety climate literature which need to be clarified. As evident in several previous studies (see e.g. Cox & Cheyne, 2000; Flin et al., 2000; Glendon & Stanton, 2000; Glendon, 2008), many variables are commonly found in both organisational safety climate and culture measurements. From the literature, there is no real consensus on how to describe the climate or culture of an organisation.

In the literature, few attempts have been made to differentiate between culture and climate. Culture reflects belief or value, while climate relates to perception or attitude (Guldenmund, 2000, 2007). safety climate is described as a "snapshots" of safety culture at a specific time (Flin et al., 2000). According to Andreas et al. (2016), climate emanates from psychometric tradition, while culture originates from sociological and anthropological tradition. These differences as found in the literature only point to the methodological relationship between the two concepts rather than the theoretical aspects. However, given the limited theoretical underpinnings on the discrimination of safety climate and safety culture, scientific efforts are required to conceptually establish the clarities of the two concepts.

Zohar (2010) identified relative priorities as one of the key attributes of safety climate that emerging studies on methodological issues should take into consideration. Zohar argues that operationalisation of safety climate should focus on the nature of relationship between policies, procedures and practices in relation to safety which must take into consideration rules and procedures associated with safety competing with other operational demands. It is found in extant safety climate literature focusing on the oil and gas industry (see e.g. Mearns et al., 1997; Fleming, 2001; Mearns et al., 2001; Mearns et al., 2003; Bayire, 2016) that climate perception variables hardly relate to the nature of relationship between the relative priorities among the dimensions rather than considering the individual variables in isolation. Retrospectively, reports on causes of major disasters in the oil and gas industry indicate that pressure for increasing production competes with ensuring safe operations (e.g. BP Texas Explosion in 2005 (Baker, 2007); Deepwater horizon disaster in 2011 (DHSG, 2011). One must compare an immediate profit gain to an accident resulting to concurrently loss in production, lives, environmental pollution and the potential impact on the organisation's reputation. It makes economic sense to sacrifice the immediate economic gain for safety. Emerging studies need to consider construction of safety climate variables from the perspective of how management choose between production/cost demands and that of the organisational safety policies, procedures and practices requirements. This is because in a practical sense, a high safety climate perception score favouring management's relative choice for production/cost as against compliance of safety rules and procedures could suggest a weak indicator for safety performance. The main challenges in safety research is to find the factors and process that influences safety climate. There have not been much studies on safety climate as a leading indicator for major accident risks.

2.4 Safety Climate as a Leading Major Accident Risk Indicator

To avoid accidents from occurring, one important strategy is to be incessantly vigilant through the use of indicators (Øien et al., 2011). Safety indicators are developed to mainly monitor the level of safety in a system, to motivate action, and to provide the necessary information for decision-makers about where and how to act (Skogdalen et al., 2011). In the oil and gas industry, the common safety indicators traditionally used may include: *Fatal accident rate, Lost time injury frequency,* and *Total recordable injury rate* and supplemented by hydrocarbon release statistical information (IOGP, 2015; Tamim et al., 2017). Occupational accidents descriptively are summarized as trips, slips and falls (Skogdalen et al., 2011), whilst major accidents are "adverse events such as major leaks/releases, fires, explosions or loss of structural integrity, leading to multiple deaths and/or major damage to the environment or property" (Amyotte et al., 2016, p.1). There are common characteristics associated with major accident cases: they have relatively low frequencies but extremely severe consequences (Amyotte et al., 2016); their occurrences were not due to unknown physical or chemical process hazards but in all cases the hazards were known for long time; why they continue to occur are mainly characterised by management quality, organizational and human factors (Knegtering & Pasman, 2009); they are caused by multiplicity of flaws, lacks and deficiencies (Reason, 1990). The controversial issues characterizing safety indicators measurement involve whether managing indicators for preventing occupational accidents the same way as managing indicators for major accidents, and should safety indicators be measured retrospectively or predictively?

At least experience of past major accidents in the oil and gas industry (e.g. *Shell's chemical Company Plant Explosion in Texas in 1997, BP Texas City refinery disaster in 2005* and *Deepwater Horizon accident in 2010*) have indubitably shown that the long assumption of occupational accidents indicators as relevant indicators for major hazard risk is misleading (Baker, 2007; Skogdalen et al., 2011). Lagging safety indicators are reactive indicators for measuring potential contributing factors of accidents which uses retrospective analysis. Leading safety indicators are predictive indicators measuring potential contributing factors which involve active monitoring to achieve organisational safety outcomes. Many studies measure safety climate as a lagging indicator to assess workers' perception of the history of safety within the organisation. The reason is that retrospective designs are easier to conduct simply because of availability of previous event data (Payne et al., 2010). However, there is the need to proactively monitor potential factors that contribute to the emergence of major accident than to wait for accident to occur and before beginning to investigate its causal factors (direct indicators). Given the apparent significance of leading indicators, there has been very little development of academic research focusing on leading indicators. Some studies (see e.g Antonsen, 2009; Kvalheim et al., 2016) have criticized the inability of safety climate scores to predict major accidents. However, the link between safety climate indicators and major accidents have been poorly investigated in the literature.

Antonsen (2009) investigated the relationship between safety climate and major accident by comparing safety climate results and findings from an accident inquiry in a specific installation. The results of the safety climate scores (the pre-incident survey) indicate that "the culture of the company in question was "a culture of compliance and learning, sensitive of the risks involved and highly oriented towards safety" (p.247). The results obtained from the inquiry after the accident show an inverse assocation with the safety climate scores. In a similar study, Kvalheim et al.(2016) investigated the ability of safety climate measurements to assess the risk of major accident in the Norwegian offshore oil and gas operations. The study was conducted in three installations and the results were inclusive. In installtion A and C, positive safety climate scores were interpretated as acceptable and which did not attract further attention from the management for corrective measures. In installtion B, the results show a negative develeopment which could suggest that the safety conditions were deteriorating. The results of these studies were methodologically challenged. The studies only focused on few cases under one construct of safety climate. However, if more cases were investigated with more constructs the results could have been signifficantly different.

Contrarily, in the work of Payne et al. (2010), which investigeted the lagging and leading effects of safety climate assessment on the major acident risk resultantly gave a different perspective. The results indicated that safety climate perceptions (good routine housekeeping, the prevention of backlogs, and prompt correction of health and safety issues) were important predictors of major accident in a chemical process industry. Morever, in the works of Vinnem et al. (2010) and Kongsvik et al. (2011) on hydrocarbon leaks analysis, safety climate results were found to be a leading indicator for major accident risks. One could draw support from the 'Swiss cheese model' of accident causation (Reason, 1990), 'failed defences' is the most promising for effective prevention of organisational accident. The gaps in the defences emerge from *active failures* (ie. those unsafe acts such as error and /or procedural violations) and *latent conditions* (e.g. high workload, time pressure, inadequate skills, experience and poor equipment etc.). These latent conditions mostly exist within the defences for a long period and may be exposed by systems auditing or occurrence of incidents (Reason, 1990; 2016). Some studies have developed safety climate variables by capturing those elements of active failures and latent conditions to measure organisational safety performance (see e.g. Mearns et al., 1997; Fleming, 2001; Mearns et al., 2001; Mearns et al., 2003; Bayire, 2016). Safety climate perception reflects a distal antecedent of safety behaviour which is mediated by the more proximal drivers of safety performance (Zohar, 2010). By implication, safety climate can be used as a proactive measure to identify the organisational latent conditions of major accidents and also prevent organisational shortcomings from becoming the root cause of future accidents. Having established the measures about the failed defences, one could provide possible predictive indicators of the likehood of accidents. Again, what is more important is to develop safety climate scales that are valid and reliable to measure predictive conditions of major accident risks.

2.5 Dimensionality of Safety Climate

As a result of the multi-dimensional nature of safety climate, there is no universal accepted dimensions to measure it. In many review studies (see e.g. Guldenmund, 2000, 2007; Gao et al., 2016), the emphasis is placed on the validity of the constructs and its robust prediction of an organisational safety climate. On the development of safety climate constructs, the relatiuonship between occupational accidents and major accidents variables have not received much attention in the literature. The conditions that predict occupational accidents and major accidents are not the same because there are different nature of hazards emergence.

Table 1 presents constructs found in the literature which are relevant in influencing major accident risks in the uptream oil and gas indutry. In most major accident cases, most studies have found these constructs as imporant indicators contributing to major accidents in high-risk industries: However, ‘causes’ and ‘conditions’ of major accidents have not been clarified in the literature. Safety climate is considered as a distal antecedent of organisational safety outcome. This paper holds the view that safety climate dimensions are more skewed to reflect conditions that potentially contribute to predicting major accidents at the work environment.

Table 1: Safety Climate Dimensions for Major Accidents Risks

Constructs	Literature Source
Safety policies	Payne et al., 2010; Baker, 2007
Safety priority	Zohar, 1980; Kvalheim et al., 2016; Høivik et al. 2013
Safety training	Hopkins, 2000; Baker, 2007; CSB, 2014; Høivik et al. 2013; Kvalheim et al., 2016; Yuang, et al., 2017
Management commitment	Zohar, 1980; Vinodkumar & Bhasi, 2010; Kines, et al., 2011
Safety rules & procedures	Vinodkumar & Bhasi, 2010; Hopkins, 2011; Neal et al., 2000
Management of change	Baker, 2007; Sklet et al., 2010
Safety communication	Sklet et al., 2010; Kines, et al., 2011; Skogdalen & Vinnem, 2012
Equipment maintenance	Payne et al., 2010; Baker, 2007
Safety involvement	Høivik et al. 2013; Kvalheim et al., 2016
Safety supervision	Baker, 2007; Bhasi, 2010; Kvalheim et al., 2016
Supportive environment	Baker, 2007; Payne et al., 2010
Safety empowerement	Shannon et al., 1997; Baker, 2007; Kines et al., 2011; Wurzelbacher & Jin, 2011
Safety motivation	Vinodkumar & Bhasi, 2010; Kvalheim et al., 2016; Høivik et al. 2013
Safety behaviour	Bayire, 2016; Huang et al., 2017

3. METHODOLOGY

3.1 Sample and Procedures

The sample was drawn from a full time workforce in the Ghanaian upstream oil and gas sector from five companies. The survey questionnaires were distributed to 250 employees which eventually had a response rate of 84.8% (N = 212). Table 2 summarises the demographic details of the participants used for the study. 72.1% of the participants were male, while 27.8% were female. The mean age range of the sample was 3.0 (30-39 years). The job functioning category of the workers include: engineering professionals maintenance/craft technicians, operators, full time HSE employees, operation management, contractors and maintenance management. More than half (50.5%) of the participants had Bachelor degree qualification. In terms of area of operation, 65.6% of the participants work in offshore, while 30.7% work in onshore. 57.1% of the participants were reported to have experienced occupational accidents/injuries at their respective work environment, whiles 36% had no accident/injuries experience.

Table 2: Demographic Information of the Participants

Variable	Frequency (*N=212*)	Percentage *(100%)*
Gender		
Male	153	72.1
Female	59	27.8
Age		
Under 25	5	2.4
25 - 29	53	25
30 – 39	94	44.3
40 – 49	56	26.4
50 or above	4	1.9
Job functioning Category		
Engineering professionals	90	42.5
Maintenance/craft technicians	41	19.3
Operators	10	4.7
Full time HSE employees	16	7.6
Operation management	26	12.3
Contractors	7	3.3
Maintenance Management	22	10.4
Education qualification		
SSCE	5	2.5
Diploma	24	11.3
Bachelor Degree	107	50.5
Master Degree	70	33
Doctoral Degree	6	2.8
Area of operation		
Offshore	139	65.6
Onshore	65	30.7
Experience of occupational accidents/injuries		
Yes	121	57.1
No	78	36.8

The selected organisations were contacted through a letter seeking approval for this study to be undertaken. The survey questionnaires including the participant information sheet and informed consent forms all in envelops were presented to the companies' reception desks after approval had been granted for this study. Participation in the study was made voluntary and respondents could discontinue his participation without giving reasons. The returned questionnaired were sealed. It takes 20-30 minutes to complete the questions. Safety climate was measured at two hierarchical levels of the organizations: work group level and top management level. In the oil and gas industry, operations are assigned to work groups that is led by supervisors. Scientific research indicates that a comprehensive safety climate investigation should capture both employees' perceptions of his/her immediate supervisor (group level) and their perception of top management (organizational level) relating to safety (Brondino et al. 2012; Haung et al., 2017). This would help to identify the issues that affect safety management in the upstream sector from the employees' perspective.

3.2 Survey Instrument

The research was designed to assess the workers' safety climate in Ghana's upstream oil and gas sector and this was initially measured by using a 82-item safety climate scale. The instrument was made up of 4 sections: 'demographic information', "occupational accidents and near-misses", "workers' perception about safety", and "workers' experiences of major hazards". The instrument contains I4 constructs developed from the literature (e.g. Zohar, 1980; Baker, 2007; Vinodkumar & Bhasi, 2010; Kines et al., 2011). The prepared survey questionnaires were pilotted with 50 sample size. 11 items were deleted mainly because they were repeated and some items were positively reworded.

The final questionnaires comprised 60 items in 14 constructs: safety policies (2-items), safety priority (2-items), safety training (4-items), safety rules and procedures (2-items), management commitment (3-items), equipment maintenance (3-items), safety communication (2-items), supportive environment (3-items), safety involvement (4-items), safety empowerement (6-items), management of change (3-items), safety supervision (4-items) safety motivation (3-items), and safety behaviour (2-items). It scores a 5-point likert type scale from *strongly disagree* to *strongly agree* on "workers' perception about safety"; and from *very unsafe* to *very safe* on "workers' experiences of major hazards". The scale had a high level of internal consistency, as determined by a Cronbach's alpha of .834.

3.3 Data Analysis

The IBM SPSS v23 software was used to perform the statistical analysis required for the study. Descriptive statistics and pearson correlation were conducted for the studied constructs to establish some pattern of associations among them. Given the large number of variables under studied, factor analysis was computed to identify the latent coonstructs. The data were subjected to principal component factoring and orthogonal Varimax rotation. The analysis indicates that Kaiser-Meyer-Olkin (KMO) Measure of Adequacy was .709 suggesting that the data were appropriate for this analysis (Kaiser, 1974). Bartlett's Test of Sphericity was significant at [x^2 =1005.969, p<.000] indicating that there exist correlation among the safety climate scales. Multiple regression analysis was computed to determine stronger causal inferences from the observed relationships among the constructs. The five factors (F_1, F_2, F_3, F_4, F_5) were constituted as the independable variables and the dependable variable is the major accident risks.

4. RESULTS

The results of the statistical analysis and pearson correlation among the constructs have been presented in table 3. The high mean scores were found in the following constructs: supportive environment (M =4.32; S.D. =.432), safety priority (M=4.19; S.D. = .44), safety policies (M= 4.09; S.D. = .37), equipment maintenance (M = 4.09; S.D. = .34), and safety behaviour (M = 4.04; S.D. = 1.21). It was found that there were negative correlations among most of the safety climate constructs. Workers' perceptions of feeling "unsafe" for major accidents risks were found negatively correlated with these safety climate constructs: safety policies (r = -.18, p<0.5), safety training (r = -.04, p<0.5), management commitment (r = -.09, p<.05), equipment maintenance (r = -.15, p<.05), safety communication (r = -.07, p<0.5), safety motivation (r = -.01, p<.01), and safety behaviour (r = -.03, p<0.1).

Table 3: Descriptive Statistics and Correlations

	M	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. SP	4.09	.37															
2. PR	4.19	.44	-.19**														
3. TR	1.95	.60	-.17*	.15*													
4. RP	1.88	.32	-.59**	-.04	-.04												
5. MC	2.64	1.00	-.27**	.04	.10	-.25**											
6. EM	4.06	.34	.07	-.18**	.12	-.14*	.28**										
7. CM	3.16	1.29	.04	-.05	-.01	-.16*	.19**	.20									
8. SE	4.32	.42	-.34**	.18**	-.11	.06	-.20	-.13	-.07								
9. IN	2.47	.96	.11	.01	-.03	-.11	.31**	.22**	.16*	-.09							
10. EP	2.64	1.00	.30**	.27**	.00	-.28**	.54**	.10	.21**	-.15*	.45**						
11. MG	2.75	1.15	.23**	-.02	.06	-.24**	.51**	.08	.21**	-.20**	.42**	78**					
12. SV	2.87	1.10	.24**	-.03	-.00	-.25**	.39**	.09	.24**	-.13	.41**	.72**	.82**				
13. MO	3.62	1.06	.26**	-.01	-.08	-.20**	.22**	.04	.10	.01	.25**	.32**	.31**	.53**			
14. BE	4.04	1.21	.04	.04	-.06	-22**	-.31**	.01	.05	.10	-.20**	-.31**	-.31**	-.28**	-.10		
15. HAZ	1.7	.60	-.18*	.07	-.04	.17*	-.09	-.15*	-.07	.14*	.12	.13	.17*	.10	-.01	-.03	

N = 212, **. p< 0.01. *. P< 0.05.

Abbreviation of safety climate constructs: **SP**=Safety Policies; **PR**=Safety Priority; **TR**=Safety Training; **RP**=Safety Rules & Procedures; **MC**=Management Commitment; **EM**=Equipment Maintenance; **CM**=Safety Communication; **SE**=Supportive Environment; **IN=**Safety Involvement; **EP**=Safety Empowerement; **MG**=Management of Change; **SV**=Safety Supervision; **MO**=Safety Motivation; **BE**=Safety Behaviour. **HAZ** = Major accident risks.

The results for the factor analysis were presented in table 4 which show the factor score coefficients, the rotated factor loading and the communality coefficients. The analysis shows that 5 factors have Eigen values greater than 1 (Kaiser, 1974) with communality coefficient (h^2) score above 50%. Factor 1 (F_1) has the following constructs: *Safety supervision*, *Management of change*, *Safety empowerement*, and *Management commitment*. Factor 2 (F_2) has *Safety policies*, *Safety rules and procedures*, and *Safety behaviour*. Factor 3 (F_3) comprises *Safety priority* and *Supportive Environment*. Factor 4 (F_4) comprises *Equipment maintenance* and *Safety communication*. Factor 5 (F_5) has *Safety training* and *Safety priority*. These five factors (F_1, F_2, F_3, F_4, & F_5) as independable variables were selected for the multiple regression analysis to determine which factor has more predictive influence on major accident risks.

Table 4: Results of Factor Analysis

	Factor Score Coefficients					**Rotated FactorLoading (f)**					**Communalities (h^2=100%)**
	F_1	**F_2**	**F_3**	**F_4**	**F_5**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Communality**
SP	-.014	.408	-.282	-.165	-.118		.730				.829
PR	.068	.128	.375	-.196	.475			.531		.584	.706
TR	-.037	.009	-.094	.061	.653					.812	.687
RP	.025	-.513	-.029	-.009	-.150		-.849				.788
MC	.133	.009	-.138	.074	.215	.601					.561
EM	-.078	-.040	-.112	.599	.068				.780		.679
CM	.011	.002	.185	.525	-.057				.667		.520
SE	.043	-.035	.564	.069	-.095			.773			.633
IN	.162	-.112	.086	.204	-.074						.441
EP	.246	-.008	.007	-.049	.021	.862					.767
MG	.254	-.033	-.010	-.064	.038	.876					.790
SV	.261	-.002	.098	-.036	-.082	.876					.793
MO	.157	.150	.236	-.030	-.206						.488
BE	-.185	.373	.247	.198	-.029		.536				.572

Multiple regression analysis was used to test which factors have more predictive influence on major accident risks. As the results are presented in table 5, it is found that the model was significant, $F(5, 206) = 4.61$, $p<.001$, which accounted for 31.7% of the variance. Factor 3 (F_3) indicated a more predictive influence on major accident risks (*Beta* =180, $p< .001$). In addition, Factor 1 (F_1) shows a predictive influence on major accident risks (*Beta* =143, $p< .001$).

Table 5: Results of Multiple Regression

Predictor	**Unstandardized Coefficients** **B**	**Standardized Coefficients** Beta	**t**	**P**
F1	.085	.143	2.165	.032
F2	- .107	- .180	-2.723	.007
F3	.107	.180	2.718	.007
F4	- .070	- .118	- 1.785	.076
F5	- .024	- .040	- .607	.545

Note: $F(5,220) = 4.61$, $p<.001$, $R^2 = .101$

Factor 3 comprises these constructs: *safety priority* and *supportive environment*. Factor 1 is made up of: *safety supervision*, *management of change*, *equipment maintenance* and *management commitment*. As established in the literature (see e.g. Zohar, 1980; Baker, 2007; Høivik et al. 2013; Kvalheim et al., 2016), the prioritisation of safety and supportive environment have become important factor that contribute to major accident in the oil and gas industy. When management see safety as a value of the organisation, other equally important operational demands could be sacrificed. Safety supervision is found to have a predictive influence on major accident risks. It appears that in the various work groups in the industry, supervision practices were weak. Weak supervision practices may reflect the low attention allocated to work procedures and practices relating to ensure that maintenance are safe before such activities are initiated. For example, this became one of the key contributory factors in BP Texas City gas explosion in 2005 (Baker, 2007). Supervisors need to take actions when a worker engage in a poor safety practices and also take appropriate action in response to suggestions for process safety improvements. Given that the upstream oil and gas operations are technical and organizational complex, and dynamic, most times changes in working procedures and practices are initiated by management. Weak predictive indicator may imply that workers are not always updated fully regarding the changes in working procedures at the work environment. This factor was also found contributing to the Deep Harizon disaster in 2010 (Sklet et al., 2010; CSB, 2014). Management always needs to implement changes efficiently. Management commitment was found to have predictive influence on major accident risks. This comfirms the literature position that management commitment to safety drives existing safety performance in the organisation (Zohar, 1980; Vinodkumar & Bhasi, 2010; Kines, et al., 2011). Managers do not have to compromise safety by short-term financial goals. When near-miss or accidents are reported, management must act quickly to solve the problems.

As discussed in the ‘Swiss cheese model’ of accident causation (Reason, 1990), these constructs found in Factor 1 (F1) and Factor 3 (F3) constitute the latent conditions which mostly exist within the defences for a long period and may be exposed by systems auditing or occurrence of incidents. Exposing these latent conditions (safety priority, supportive environment, safety supervision, management of change, equipment maintenance and management commitment) would help to managers to put corrective measures in place to avoid contributing to occurrence of major accident in the oil and gas industry.

5. CONCLUSION

The study was designed to assess the current safety climate predictive influences on major accidents risks in Ghana's upstream oil and gas sector. Many workers have experienced occupational accidents or injuries at the work environment. Safety climate is found to be a leading indicator to major accident risks. The relationship between safety climate measurement and major accident risks have not received adequated research attention to clarify the discrimination between what constitutes 'condition' or 'cause' of accident causation. The results of the study indicate that safety climate measures were predictive indicators for major accident risks in the oil and gas industry. Safety priority and supportive environment was found to have high predictive influence on major accident risks. In addition, safety supervision, management of change, equipment maintenance and management commitment indicate predictive influence on major accident risks.

It suggests that managers need to allocate more attention on the realignment of the organisational safety priority and improve on the existing culture of supportive environment. There is also the need to improve on supervision practices, effective implementation of working procedures and facilities changes especially on the perspective of workers'updates, improvement on equipment maintenance and management commitment to safety in the work environmkent. The findings of this study provides valuable guidance for researchers and industrial practioners to identify mechanisms by which they can improve existing safety performance at the work environment.

This study was only limited to identifying those latent conditions that have predictive influences on major accidents risks in Ghana's upstream oil and gas industry. The antecedents of these facrtors were not explored. Futher research needs to focus on investigating the antecedents of those established predictive constructs by using using qualitative approachs. This would form part of the researcher's current research project.

6. REFERENCES

Amorin, R. & Broni-Bediako, E., 2013. Major Challenges in Ghana ' s Oil and Gas Discovery : Is Ghana Ready ?, 3(1), pp.21–25.

Amyotte, P.R. et al., 2016. Why major accidents are still occurring? *Current Opinion in Chemical Engineering*, 14, pp.1–8.

Andreas, S., Antonsen, S. & Haugen, S., 2016. Safety climate as an indicator for major accident risk : Can we use safety climate as an indicator on the plant level? *International Journal of Disaster Risk Reduction*, 18, pp.23–31.

Bayire, F.A., 2016. *The influence of safety climate and organisational learning on employees' safety risk behaviour at the Jubilee Oil Fields*. University of Ghana.

Bitsani, E., 2013. Theoretical approaches to the organizational culture and the organizational climate : Exploratory research examples and best policies in health care services. , 1(4), pp.48–58.

Bosak, J., Coetsee, W.J. & Cullinane, S., 2013. Safety climate dimensions as predictors for risk behavior. *Accident Analysis and Prevention*, 55, pp.256–264.

Brondino, M., Silva, S.A. & Pasini, M., 2012. Multilevel approach to organizational and group safety climate and safety performance : Co-workers as the missing link. *Safety Science*, 50(9), pp.1847–1856.

Dahl, Ø. & Olsen, E., 2013. Safety compliance on offshore platforms : A multi-sample survey on the role of perceived leadership involvement and work climate. *Safety Science*, 54, pp.17–26.

DHSG, 2011. *Final Report on the Investigation of the Macondo Well Blowout Deepwater Horizon Study Group*, Available at: http://ccrm.berkeley.edu/pdfs_papers/bea_pdfs/DHSGFinalReport-March2011-tag.pdf.

Høivik, D. et al., 2013. What is most important for safety climate : The company belonging or the local working environment ? – A study from the ... *Safety Science*, 47(10), pp.1324–1331.

Høivik, D. et al., 2009. What is most important for safety climate : The company belonging or the local working environment ? – A study from the Norwegian offshore industry. *Safety Science*, 47(10), pp.1324–1331.
Hopkins, A., 2000. Lesson from Longford: Esso gas plant explosion. Sydney: CCH Australia Ltd.
Huang, Y.H. et al., 2017. Safety Climate: How can you measure it and why does it matter? *Professional Safety*, (January 2017), pp.28–35.
Hystad, S.W., Bartone, P.T. & Eid, J., 2014. Positive organizational behavior and safety in the offshore oil industry: Exploring the determinants of positive safety climate. *The journal of positive psychology*, 9(1), pp.42–53.
Kaiser, H.F., 1974. An index of factorial simplicity. *Psychometrika,* 39, pp.31-36
Kines, P., Lappalainen, J., Mikkkelsen, K.L., Olsen, E., et al., 2011. Nordic safety cliamte questionnaire (NOSACQ-50): A new tool for diagnosing occupational safety climate. *International Journal of Industrial Ergonomics*, 41, pp.634-646.
Kvalheim, S.A. & Dahl, Ø., 2016. Safety compliance and safety climate : A repeated cross-sectional study in the oil and gas industry. *Journal of Safety Research*, 59, pp.33–41.
Mihajlovic, I., 2013. Developing a Questionnaire for Measuring Safety Climate in the Workplace in Serbia. , 19(4), pp.631–645.
Norman, I.D. et al., 2015. Review of Catastrophic Fires and Risk Communication, Ghana. *Advances in Applied Sociology*, 5, pp.167–177.
Øien, K., Utne, I.B. & Herrera, I.A., 2011. Building Safety indicators : Part 1 – Theoretical foundation. , 49, pp.148–161.
Rémi, D., Ngueutsa, R. & Mbaye, S., 2015. Safety climate , perceived risk , and involvement in safety management q. *Safety Science*, 77, pp.72–79. Available at: http://dx.doi.org/10.1016/j.ssci.2015.03.009.
Shannon, H.S, Mayer, J. & Haines, T., 1997. Overviewof the relationship between organisation and workplace factors and injury rates. *Safety Science*, 26(1), pp.201-2017.
Shea, T., De Cieri, H., Donohue, R., Cooper, B. & Sheehan, C., 2016. Leading indicators of occupational health and safety: An employee and workplace level validation study. *Safety Science,* 85, pp. 293-304
Sklet, S. et al., 2010. Monitoring of Human and Organizational Factors Influencing the Risk of Major Accidents. *SPE International*, (SPE 126530), pp.1–8.
Skogdalen, J.E., Utne, I.B. & Vinnem, J.E., 2011. Developing safety indicators for preventing offshore oil and gas deepwater drilling blowouts. , 49, pp.1187–1199.
SPE, 2015. An Analysis of Global Safety Trends in the Oil and Gas Industry - Impacts. *Society of Petroleum Engineers International*, (SPE-176502-MS), pp.1–18.
Tamim, N. et al., 2017. A framework for developing leading indicators for offshore drillwell blowout incidents ☆. *Process Safety and Environmental Protection*, 106, pp.256–262.
Ocloo, D. R., 2017. Explosion at TOR, *Graphic Online,* Accessed on 15th March 2017 at: (http://www.graphic.com.gh/news/general-news/explosion-at-tor.html).
Øien, K., Utne, I. B., & Herrera, I. A. (2011). Building Safety indicators : Part 1 – Theoretical foundation. *Reliability Engineering and System Safety*, *49*, 148–161.
Tamim, N., Laboureur, D. M., Mentzer, R. A., Rashid, A., Mannan, M. S., Texas, A., & Station, C., 2017. A framework for developing leading indicators for offshore drillwell blowout incidents. *Process Safety and Environmental Protection*, *106*, pp.256–262.
Tetteh, D., 2017. Fire guts Finesse Oil yard …12 fuel tankers burnt, The Ghanaian times, Accessed on 15th March 2017 at: http://www.ghanaiantimes.com.gh/fire-guts-finesse-oil-yard-12-fuel-tankers-burnt/).
Vinnem, J.E., Hestad, J.A., Kvaløy, J.T., et al., 2010. Analysis of root causes of major hazard precursors (hydrocarbon leaks) in the Norwegian offshore petroleum industry. *Reliability Engineering Systems Safety*. 95 (11) pp.1142–1153.
Vinnem, J.E., Seljelid, J., Haugen, S., and Husebø, T., 2007a. Analysis of Hydrocarbon Leaks on Offshore Installations, ESREL, Stavanger.
Vinodkumar, M.N. & Bhasi, M., 2010. Safety management practices and safety behaviour: assessing the mediating role of safety knowledge and motivation. *Accident Analysis and Prevention*, 42, pp.2082-2093.
Visser, J., 1994. *Managing safety in the oil industry–the way ahead.* Paper presented at the 14th World Petroleum Congress.
Wurzelbacher, S. & Jin, Y., 2011. A framework for evaluating OSH program effectiveness using leading and trailing metrics. *Journal of Safety Research*, 42, pp.199–207.
Zohar, D., 1980. Safety climate in industrial organizations: theoretical and applied implications. *Journal of Applied Psychology*, 65, pp.96–102.
Zohar, D., 2011. Safety climate: conceptual and measurement issues. In. Quick, J. C & Tetrick, L. E. (eds.), *Handbook of occupational health psychology*, 2nd ed. (pp. 141–164). Washington, DC: American Psychological Association.

Zohar, D., & Luria, G., 2005. A multilevel model of safety climate: cross-level relationships between organization and group-level climates. *Journal of Applied Psychology*, 90, pp.616–628.