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Predicting Safety Performance using Safety Culture Assessment in Oil/Gas Multinational Companies

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Abstract: This study assesses the safety culture of oil/gas employees in Saudi Arabia to investigate factors deemed necessary to sustain satisfactory safety performance in multinational companies. Especially since the safety performance is unsatisfactory in high-risk hazardous worksites in Saudi Arabia. Sixteen percent of injuries, deaths, and accidents that occurred among the Saudi workforce were in manufacturing that includes oil/gas. According to [1], the safety culture is the core element that affects workers attitudes and behaviours that is also needed to sustain satisfactory safety performance. Research is also needed to understand factors that affect workers motivation, and monitors their safety behaviours. Thus, assessing oil/gas employees' safety performance is necessary to identify safety performance improvement measures and opportunities for oil/gas workers in multinational companies. The study develops two instruments, theoretical model and survey, which are grounded in safety culture literature. Results are beneficial to companies that employ workers in high-risk hazardous worksites.

Keywords: Safety culture, and safety performance

I. INTRODUCTION

Oil and gas is the leading industry that is considered the backbone of the Saudi Arabian economy. This sector sustains current and future giant projects that provide long-term jobs in diverse fields. The news and records report [2] that the safety performance of oil/gas is very disappointing. Nevertheless, Saudi Arabia is one of the major oil and gas producers in the world, and the largest in the Gulf Cooperation Council (GCC).

In the past few years, there were several tragic accidents in the Saudi Arabian oil/gas industry. In 2007, an explosion and fire at the Hawiyah plant in Eastern Saudi Arabia killed 28 workers and injured nine employees while performing maintenance on a natural gas pipeline [2]. In 2015, a fire at the Saudi Aramco residential complex in Khobar, Saudi Arabia killed ten employees, and injured 259 [3]. Further, in 2016 [4] reported eight injured workers during a fire at an oil terminal in Ras Tanura, Saudi Arabia.

The General Organization for Social Insurance (GOSI) [5] states the manufacturing industry including oil/gas is responsible for 16% of the total work-related injuries, deaths, and accidents that occurred among the Saudi workforce. Thus, investigating safety performance is a necessity since this effort supports improving safety performance in high-risk accident work sites such as oil/gas. Hence, research is lacking that investigates the effect of the safety culture among employees in oil/gas, their motivation level, and monitors their safety behaviours.

The following three objectives guided this research. 1) To assess the safety culture and develop a model that is sustainable through recurrent assessments. 2) Investigate the influence of oil/gas employees' safety culture on safety performance regarding error behaviours and attitudes toward violations. 3) To examine the impact that workers' safety motivation level have on the relationship between safety culture and safety performance within oil/gas work sites in a multinational company such as Saudi Arabia.

This research employs three phases to accomplish the study objectives. Phase-1 consists the development of two instruments (e.g. theoretical model and a survey), and data collection. Phase-2 consists of conducting three data analyses (e.g. descriptive statistics, multi-co linearity, Confirmatory Factor Analysis (CFA). Phase-3 consists of using Structural Equation Modelling (SEM) to validate the measurement model against five hypotheses to ensure the model is factual.

II. BACKGROUND AND METHODOLOGY

PHASE-1: DEVELOPMENT OF INSTRUMENTS AND DATA COLLECTION

Safety Culture Assessment Model and Survey

This section describes the components in the theoretical model, which is termed Safety Culture Assessment Model (SCAM) citing applicable literature and relevant studies that used questionnaires in similar contexts; thus, the researcher discuses adopting questions for the safety culture survey. This section opens with a discussion of the eight variables in the theoretical model. Safety culture is an independent variable that consists of five factors that includes management/organization commitment towards safety, workers attitude toward safety, co-workers' support, work stress and safety management system. Safety culture is also a dependent variable that influences employees' safety motivation, workers' error behaviour and employees' attitude toward violation behaviours. Employees' safety motivation toward safety is the mediating variable between safety culture and their error behaviours likewise workers attitude toward violations. The following section describes the independent and dependent variables that makes up the theoretical model.

Independent Variables

1) Management Commitment - Management commitment toward safety is the first safety culture factor in the conceptual model. Management commitment includes support, level of commitment, and dedication to safety as observed by oil/gas employees. Several researchers agree that management support and commitment towards safety is the most significant characteristic when measuring a safety climate that is a sub-factor of a safety culture [1], [6], [7], [8], and [9]. Thus, measuring levels of support and the commitment of management towards safety can aid in assessing the safety culture of oil/gas employees in Saudi Arabia. This study adopts nine questions from the survey of [9] to measure management commitment toward safety. Two questions about supervisor support were duplicates. Therefore, for consistency and in support of different managerial levels, the researcher deleted this question and included it in management commitment because supervisor support and management commitment are at the same level. Cronbach's alpha reliability score for this factor is 0.84, which is in alignment with [9]. Questions for the management commitment construct focused on employees' comprehension of safety management commitment and support. The survey questions also measures top management attitudes on how they contend with daily safety issues.

2) Workers Attitude - Cooper (2000) [10]; and Fogarty and Shaw (2010) [8] suggests individuals' perception of their safety morals and expectations explains their attitudes toward safety. In this research, attitude is associated with employees' perspective of safety as a value and an approach. Therefore, this research anticipates that the safety employees will have different attitudes because of their differing personalities and backgrounds [10]. Research also supports that employees' attitudes influence their manners and actions as their attitude is a reflection of their ethics and principles [10], [11], and [12].

Hall (2006) [7] asserts that behaviour is subjective and assessed as either a positive or a negative behaviour. An assessment of behaviour is based on evaluations of attitudes that form values and beliefs. Workers' attitudes toward safety questions measures their evaluation of hazards in the workplace, such as use of safety apparatus practices, their inner commitment to safety values, opinions and determination to follow safety rules, and attitudes toward errors and violations while following safety regulations. Thus, the model developed for this study includes employees' attitudes, which is another component of safety culture often used to standardize a comprehensive safety culture, which relies on existing theoretical models [1], [10], [13], and [14]. Therefore, to measure workers' attitudes toward safety, this research adopted seven questions from the risk survey of [7].

3) Co-workers Support - The third safety culture factor is co-workers' support, natural or accepted is a way to accomplish a specific task among a group of individuals or in a social environment [8], and [15]. Co-workers' can influence workers safety behaviors and their safety culture. Organizations have a dynamic culture due to diversity of age, nationality, education, work position, and work experience that can also influence co-workers support [15].

Beliefs and actions of individuals can influence attitudes of group members through their interaction between members during events and discussions of work rules and regulations [8]. Helmreich, and Merritt (2001) [15], [6], [13] and [16] states that individuals mostly develop undesirable norms. Therefore, this study adopted six workmate support questions from [17]. Accordingly, their reliability Cronbach's alpha value was more than 0.70. The researcher modified one question to accommodate the Saudi Arabian cultural environment. Further, the latent variables for co-workers' support measures the priority level of peer's safety and their perceived safety commitment level.

4) Work Stress - The fourth safety culture factor is work stress that defines the workers' comprehension of the easiness or complication involved in following safety guidelines and rules under tension, which translates to loss of cost and time. Safety compliance and dedication is the result of workers practices and intentions about barriers formed from not adhering to safety rules. The work stress factor assesses the availability of safety apparatuses and the suitability of safety rules practiced when time and cost pose constraints [18]. Seo, Torabi, Blair, and Ellis (2004) [9] debated whether employees could accomplish their jobs by following safety guidelines and regulation that could influence their performance that could cause stress. External factors can also cause employees safety level to decrease such as lack of time, shortage of employees, deficiency of tools, and scarcity of liquidity creates work stress. Therefore, including work stress in employees' safety performance is not only for top management but also for all employees including workers. Consequently, recognizing and acknowledging causes of work stress will enhance a safety culture [18].

In this research study, work stress is a latent factor measured with six questions to understand associated issues from workers' perspectives. These concerns include pressure as seen by workers, the volume of work, the balance between allocated workload and the employees' abilities, barriers in implementation of safety guidelines, employees' adeptness following safety regulations, and availability of essential safety apparatuses. This study adopts seven questions from [9] that include work stress factors. The Cronbach's alpha reliability value in their study was more than 0.80. The researcher modified a few phrases to align with the context of oil/gas industry worksites, and deleted a couple questions due to similarities. Furthermore, this study measured workers knowledge of adhering to safety rules with one question that analyses workers' capability to follow safety rules and examines availability and accessibility of required safety apparatuses. Lastly, work stress as a latent factor that has seven questions.

5) Safety Management System - Evaluating the safety management system (SMS) is a crucial component in assessing the safety culture in the oil/gas industry. Since the SMS is a latent factor, this research evaluates four significant safety-management system fundamentals, which are safety rewards, safety implementation and disincentives for risky concerns, subcontractors' safety compliance, and safety system responsibility and obligation. The literature show that questions adopted for this factor assessed the safety culture in construction corporations. However, because both industries are high-risk environments these questions are also applicable to the oil/gas industry [18]. These researchers fitted their safety culture model by utilizing factor analysis iterations until the model was a good fit. Their questions relied on previous safety culture models as well. They also reduced the number of their questions from 54 to 19 using an exploratory factor analysis (EFA) with several iterations that had a high correlation with safety culture [18].

The first sub-factor in the SMS is safety awards or incentives. Therefore, this study adopted four questions to collect management safety feedback (e.g. employees' feelings of appreciation after performing their jobs in a safe manner, frequency of incentives, employees' evaluation of incentives provided by management) [18].

Secondly, the literature supports enforcing safety and discourages risky manners in safety management assurance and consistency because risky manners will result in a penalty for practicing an unsafe task regardless of the occurrence of an accident. Further, safety performance and corrective actions that result from violations that occurred or exerted in an unsafe manner is a beneficial tracking tool. This sub-factor includes three questions to measure employees' perception and understanding of tolerance for and absence of unsafe behavior, steadiness of corrective actions for risky behavior, and the safety regulation enforcement level when a violation occurred with no accidents [18].

The third sub-factor for the safety management system is subcontractors' safety compliance. Subcontractors have a vital role in attaining a positive safety level in large companies. Their role is defined as an obligation toward safety plans and an adequate contribution in fulfilling safety rules. This study adopted two questions will measure safety compliance of subcontractors, which consists of the subcontractors' level of concern about safety obligations, frequency of safety training sessions and meetings for newly employed workers [18].

The last sub-factor included in the SMS in oil/gas worksites are rules, obligations, and accountability. These depend on management implementing effective safety programs that includes an analysis of and the prevention of hazards. Besides safety obligations and accountability measures, safety effectiveness through regulating safety responsibilities and the level of workers concerns toward practical safety [18]. This study adopted five questions that will measure safety obligation and accountability in the SMS.

The last safety culture factor is the safety management system (SMS). The study adopted 17 questions to measure the fundamental characteristics of a comprehensive SMS. This factor is very important due to the nature of the oil/gas industry from a technical aspect and surroundings of the workplace.

Dependent Variables

6) **Employees Safety Motivation** - is a latent factor in the theoretical model, and a mediator variable between safety culture and workers safety performance used to quantify workers error behaviour and workers attitude toward violation behaviour. Safety motivation variables concentrate on the role of employees' communication and management to inspire safety practices and increase employees' safety awareness. This research anticipates that safety culture will affect employees' safety motivation due to their direct relationship.

Safety culture involves employees' morals and beliefs toward safety and their outcomes are actual behaviours. Thus, safety culture is relevant to safety motivation and safety devotion because motivation is a product of inner values and beliefs that influence the current culture [1], [6], and [19]. The study adopted five questions to measure employees' safety motivation, which has an internal consistency reliability value of 0.72 [20]. Safety motivation is also a mediator between safety performance and managerial safety procedures. Findings showed a significant relationship between safety climate measures and safety motivation that comprises safety commitment and communication [20]. Safety motivation questions essentially concentrates on priority levels and status of workers' impression toward safety as an embedded value influenced by safety culture.

7) **Employees Error Behaviour** - This research measures safety performance using two variables, employees' errors and their attitudes toward violation behaviours. The error behaviour construct is measured using [9's] unsafe behaviour factor to obtain causes of error behaviour such as decision, skills, or communication errors, which lead to unsafe error behaviour [16]. Four questions adopted from the survey of [9] measures employees' misconduct behaviours. These researchers focused on measuring decision-making abilities of workers to adhere to safety rules regularly, workers skills to work safely; lastly, perceptional error arises when workers are willing to perform safely under pressure or when ambiguity exists concerning work specifications.

8) **Employees Violation Behaviour** - The second factor used to measure safety performance is workers' attitudes toward violation as well as employees' error behaviour constructs. Attitude is the workers' way of thinking regarding safety violation while performing a job in less time without following safety standards and procedures specified under time or cost constraints. Attitude also reflects workers' willingness to report any safety violation to management when their peers do not commit. This study adopted five questions from [8] to measure employees' attitudes toward violations such as the frequency of violation behaviour. These questions focus on the wilfulness of workers' attitudes to violate a safety regulation and their responsibility to perform work safely even under time and cost pressures.

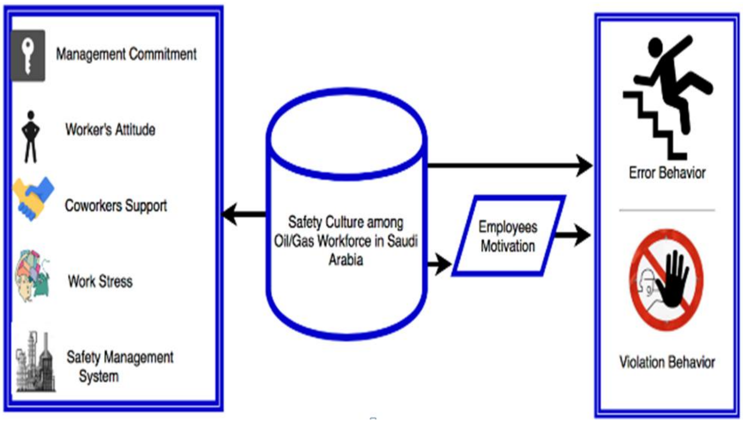

Fig. 1 Theoretical Safety Culture Assessment Model (SCAM)

Figure 1 is an illustration of the theoretical model used to investigate the role of employees' safety motivation as a mediator between safety culture, and safety performance. Assessing safety culture with the theoretical model supports predicting safety performance in the Saudi Arabian oil/gas workforce. Figure 1 also provides an overview of the study variables previously discussed.

The model termed "Safety Culture Assessment Model (SCAM) will also undergo further analysis later in this publication to test five research hypotheses that follows linking each to this research and applicable literature.

Hypotheses and Link to Theoretical Model

H1: Safety culture has a significant impact on workers' safety motivation in oil/gas work sites.
As an organizational factor, management's safety commitment has a vast impact on workers' safety behaviours regarding violations. Further, committing errors or violating behaviours are the result of employees' perception of safety culture [12].

Therefore, H2 and H3 propose safety culture influence on workers' error behaviours and their attitude toward violation behaviours in oil/gas work sites.

H2: Safety culture has a significant impact on workers' error behaviours in oil/gas work sites.
H3: Safety culture has a significant impact on workers' attitude toward violations in oil/gas worksites.

H4 and H5 link the impact of workers safety motivation to safety culture and safety performance. Hence, H4 examines the impacts of workers' safety motivation between safety culture and workers error behaviours in multinational oil/gas work sites. H5 investigates the influences of workers' safety motivation between safety culture and workers' attitude toward violations in the oil/gas sites.

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H4: Workers’ safety motivation has a significant effect on the relationship between the safety culture and their error behaviours in oil/gas sites.
H5: Workers’ safety motivation has a significant effect on the relationship between the safety culture and their attitudes toward violations in oil/gas.

Summary of Safety Culture Survey

The aim of the survey is to measure several safety culture factors in multinational oil/gas work-sites in Saudi Arabia. Research shows that safety culture assessments through accidents records are not trustworthy for determining the strength and weakness of a companies’ safety culture. Neither is depending on accident reports, data collected from preceding accidents by individuals with biased information and discrepancies is not a reliable tool to assess a safety culture [15]. Therefore, this research assesses the safety culture components using a theoretically sound survey to analyse human behaviour, and environmental mechanisms that rely on reciprocal safety culture models [1], [10], [14], and [18].

According to Molenaar, Park, and Washington (2009) [19], questionnaire surveys are the most widely used instruments to assess the safety culture in many industries like manufacturing, construction, nuclear plants, and transportation. In terms of time and cost, surveys are the most beneficial and ideal technique for gathering data from workers in hazardous industries, specifically in large companies. Therefore, this study adopted questions from several diverse surveys (discussed in the theoretical framework) to measure employees’ safety culture, safety motivation, error behaviours and attitude toward violations.

The survey also includes demographic information such as nationality, language, age, education level, work experience, work position, and frequency of safety training. Reliability of the survey is also important. Therefore, the five surveys adopted have different reliability measures between 0.70 and 0.94, which is value added for the survey developed for this research. The survey was also pre-tested with two groups. The first group was three English-speaking students who provided feedback on the survey regarding easiness of reading, clarity of the questions. Feedback and comments received were on vocabulary, structure of the survey, and flow of the questions. The second group were three Saudi Arabian oil/gas employees whose English is their second language. Their comments and suggestions were included in the final survey before launching online via Survey Monkey.

The final survey consists of 59 items. All the questions are open-ended except one question. The other questions are scored using a 5-point Likert scale for with ‘5’ being ‘strongly agree’ to ‘1 being strongly disagree. In respect of the page limitation of this publication, Table 1 is provided as an illustration of the management commitment section of the safety culture survey.

Data Collection: Data collection consisted of two methods, delegation and electronic. 1) The delegation process involved using middle management personnel in multinational oil/gas worksites to distribute the survey to employees and return once completed. 2) The electronic process included distributing the surveys via email to oil/gas project managers, engineers, and supervisors. Each communication methods contained pertinent information about study and the questionnaire. Both methods increased the response rate and accommodated the workers by providing an optimal way to accommodate their circumstances and needs.

Table 1: Management Commitment Section Of Safety Culture Survey

Statements	**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree(1)**
Management Commitment					
My company's management provides efficient safety training for the employee.					
If I report a mistake to my supervisor, management support's me.					
Management stimulates worker's to report every incident to the supervisor.					
Management strongly support work safety					
Manager's support job safety even if it delays work.					
My manager sometimes ignore violations of work safety.					
My manager frequently negotiate unofficially with workers about work safety.					
Management leads employees to safety rules sensitivity.					
My manager pays attention to my opinions to improve work safety					

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Vol. 5, Issue 8, August 2018

Participants: Participants were 247 employees in the oil/gas industry in Saudi Arabia; they were of nine nationalities. Their positions from highest to lowest number are operators, employees, technicians, supervisors, engineers, and manager. Their ages ranged from under 25 years of age to 50 years of age. Their education level by highest percentage to lowest are high school diploma (92%), below high school (67%), associate degree (66%), Bachelor's degree (21%), and Graduate degree (1%).

PHASE-2: STATISTICAL ANALYSES

Phase-2 consists of using two analyses (multicollinearity analysis, and confirmatory factory analysis (CFA) to examine the research variables.

Multicollinearity Analysis: Spearman's correlation matrix was used to determine whether multicollinearity issues exist among the safety culture latent factors and variables. According to [17], affirming sufficient correlations among latent variables is critical and should be done during an early phase of analysis. Variables with correlation coefficients above .80 were deleted from the model unless the researcher deemed it necessary to retain them in the model. In respect of the page limitation for this publication, Figure 2 shows a segment of the survey. In respect of the page limitation of this publication, the results of the management commitment factor are provided; however, all the latent variables in the study were checked for multicollinearity issues.

Management Commitment: This latent variable describes employees' perspective of management support and dedication to safety. Management commitment is comprised of nine variables that address management commitment, attitude, and reactions to daily operational safety issues. Figure 2 shows the Spearman correlation matrix used to check for multicollinearity issues among this factor. At the 0.05 level, the correlation coefficients between the nine indicators for management commitment are significant. The highest correlation coefficient among all indicators was 0.638, which is less than the multicollinearity cut-off of 0.80. Hence, multicollinearity did not occur among the management commitment observed variables.

Confirmatory Factor Analysis (CFA) aided in confirming and evaluating each safety culture factor for acceptable reliability. Safety culture in Saudi Arabian oil/gas industry is a second-order exogenous independent latent variable. Conceptually, safety culture has five first-order elements (e.g. management's commitment, worker attitude, co-workers' support, work stress, and safety management system). In respect of the page limitation of the publication, management commitment is provided as an illustration; however, all the dependent and independent variables in the study underwent CFA.

Management Commitment - consists of nine observed variables that explain safety management support in the Saudi Arabian oil/gas industry. After conducting CFA, the researcher checked the factor loadings for each observed variable to ensure that each indicator represents the management commitment factor. Four factor loadings for management commitment indicators were higher than 0.5, see Figure 3. The remaining five factor loadings were less than 0.5 (e.g. MC_1, MC_2, MC_6, MC_7, and MC_8) were deleted from the model. Since there are four indicators still in the model, this meant re-checking the model fit indices. Then, the initial management commitment model fit was within an acceptable range. In order to improve the model fit more required implementation of the model with only the four satisfactory indicators. Since SAS allows parameters to link freely using the covariance matrix, we can improve the Chi-square index (CSI) and decrease the current value [17]. Figure 3 also depicts the revised management commitment model that consists of four indicators and associated factors loadings, which are close to the initial model. Factor loadings for the observed variables range from 0.54 to 0.67, respectively. This completes the evaluation of the model fit for the revised management commitment model.

Spearman Correlation Coefficients, N = 247
Prob > |r| under H0: Rho=0

	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6	MC_7	MC_8	MC_9
MC_1	1.00000	0.31722	0.20551	0.28284	0.26377	-0.16137	0.00835	-0.06724	0.19512
MC_1		<.0001	0.0012	<.0001	<.0001	0.0111	0.8962	0.2925	0.0021
MC_2	0.31722	1.00000	0.30929	0.20748	0.27442	-0.12031	-0.08652	-0.12370	0.26370
MC_2	<.0001		<.0001	0.0010	<.0001	0.0590	0.1753	0.0522	<.0001
MC_3	0.20551	0.30929	1.00000	0.47761	0.32048	-0.12392	0.04597	-0.00365	0.31766
MC_3	0.0012	<.0001		<.0001	<.0001	0.0518	0.4720	0.9544	<.0001
MC_4	0.28284	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04193	0.00804	0.33975
MC_4	<.0001	0.0010	<.0001		<.0001	0.0254	0.5119	0.9000	<.0001
MC_5	0.26377	0.27442	0.32048	0.40903	1.00000	-0.18037	0.02333	0.02036	0.42909
MC_5	<.0001	<.0001	<.0001	<.0001		0.0045	0.7152	0.7502	<.0001
MC_6	-0.16137	-0.12031	-0.12392	-0.14222	-0.18037	1.00000	0.56038	0.50445	-0.17955
MC_6	0.0111	0.0590	0.0518	0.0254	0.0045		<.0001	<.0001	0.0046
MC_7	0.00835	-0.08652	0.04597	0.04193	0.02333	0.56038	1.00000	0.63784	-0.13043
MC_7	0.8962	0.1753	0.4720	0.5119	0.7152	<.0001		<.0001	0.0405
MC_8	-0.06724	-0.12370	-0.00365	0.00804	0.02036	0.50445	0.63784	1.00000	-0.04788
MC_8	0.2925	0.0522	0.9544	0.9000	0.7502	<.0001	<.0001		0.4538
MC_9	0.19512	0.26370	0.31766	0.33975	0.42909	-0.17955	-0.13043	-0.04788	1.00000
MC_9	0.0021	<.0001	<.0001	<.0001	<.0001	0.0046	0.0405	0.4538	

No Issues Detected!

Fig. 2. Management Commitment Factor

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Additionally, all the latent factors in the study were evaluated according to the fit indices in Table 2. Management commitment is also used here as an example. As shown in Table 2, the initial model had acceptable model fit indices before removing five observed variables that were less than 0.5; however, the revised model showed an even better fit level for all the fit indices for this factor. Cronbach's alpha for the initial and revised models was 0.588 and 0.713, respectively. However, Cronbach's alpha for the revised model is higher than the recommended level of 0.70, which means the management commitment variable is a reliable factor.

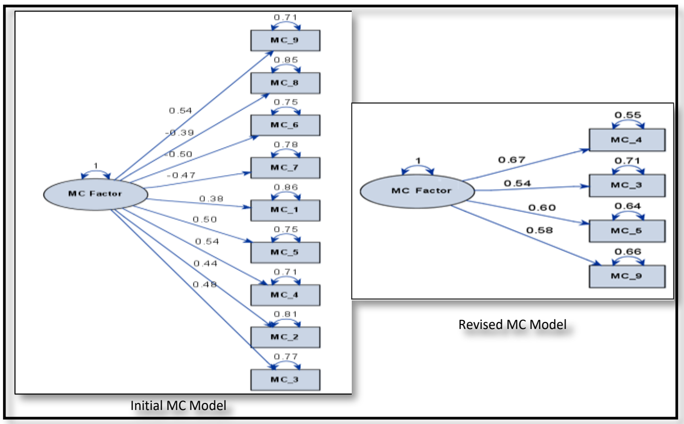

Fig. 3. Management Commitment Model

Table 2
Model Fit Indices for THE Management Commitment Model

Fit Index	Initial Model	Revised Model
Chi-square Index (CSI)	297.3733	6.4261
Chi-square Index DF	27	2
Chi-square/DF	11.0138	3.2131
Goodness of Fit Index (GFI)	0.7865	0.9869
Root Mean Square Error of Approximation(RMSEA)	0.2071	0.0141
Cronbach's Alpha	0.5878	0.7129

After confirming and evaluating each safety culture factor for acceptable reliability, nine factor loadings were less than 0.50. These were deleted from the model (e.g. MC_3, WA_2, CS_1, SM_4, SM_7, SM_13, SM_15, SM_17, and SV_2). Then, the model was revised, which is shown in Figure 4.

Based on GFI of 0.7568, the safety culture model had adequate fit measures. In contrast, chi-square ($\chi 2/df$) = 3.135 and RMSEA = 0.068 were within a tolerable fit range. Hence, applying modifications trials are necessary to improve the model fit, which is the focus of Phase-3.

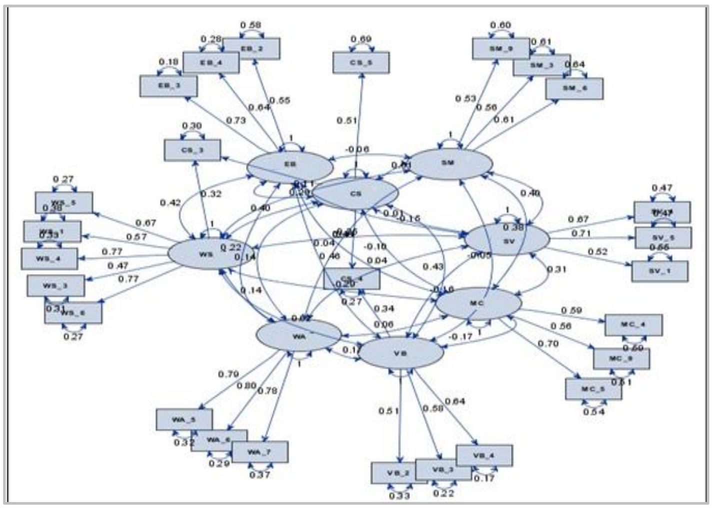

Fig. 4. Final Safety Culture Assessment Model for CFA

III. PHASE-3: STRUCTURAL EQUATION MODELLING (SEM)

Phase-3 employed SEM to create the structural model to test five research hypotheses. All the independent, dependent variables that were retained in the final CFA model were included in the structural model including demographic variables. Analyses included a path analysis and three measures of goodness of fit (e.g., GFI, CSI, and RMSEA). The path analysis was used to assess connections between each latent variable and the research hypotheses. The goodness of fit measures aided in examining and validating the fitness of the initial safety culture structural model. Figure 5 is a schematic of the initial safety culture structural model that shows the effect of safety performance through error and violation behaviour. According to the fit criteria, GFI = 0.792, RMSEA = 0.2183, and $\chi 2/df = 28.42$, the model did not have a good fit because several regression paths were not statistically significant at the 0.05 level. Thus, five paths were removed from the model. 1) The path from safety training and work position to safety motivation, error behaviour, and violation behaviour were removed safety training and work position. 2) The path from education to error behaviour and safety motivation was removed from the model. 3) The path from education to error behaviour and safety motivation was removed from the model. 4) The path from nationality to safety motivation was removed from the model. 5) Lastly, two indicators and three regression paths were removed from the final safety culture structural model.

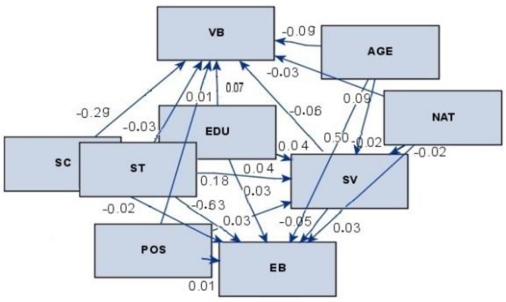

Fig. 5. Initial Safety Culture Structural Model for SEM

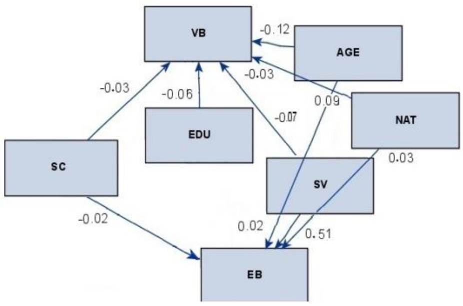

Fig. 6. Final Safety Culture Structural Model for SEM

Figure 6 is a schematic of the final safety culture structural model. Based on the fit criteria, the final safety culture structural model has a significantly better fit (GFI = 0.959, RMSEA = 0.041, and $\chi 2/df = 1.93$). Table 3 gives the model fit measures for the initial and final structural models. After removing insignificant demographic indicators and regression paths, the final model showed a noticeably enhancement according to the fit indices.

The final structural model revealed that safety culture has a significant positive effect on safety motivation ($\beta = 0.18$). Therefore, safety culture does improve safety motivation in the Saudi Arabia oil/gas industry. Safety culture also has a negative significant effect on violation behaviour ($\beta = -0.29$), which confirms the safety culture influence on decreasing violation behaviour. On the other hand, safety culture does not have a direct significant effect on error behaviour ($\beta = -0.02$), which indicates that error behaviour cannot be directly predicted from safety culture.

Table 3
Fit Indices for safety culture structural model

Fit Index	Initial Model	Final Model
Chi-square Index (CSI)	539.8886	13.5002
Chi-square Index DF	19	7
Chi-square/DF	28.4152	1.9286
Goodness of Fit Index (GFI)	0.7924	0.9589
Root Mean Square Error of Approximation (RMSEA)	0.2183	0.0412

Safety motivation has a significant effect on error behaviour (β = 0.51), which substantiate the essential role of safety motivation to decrease errors. On the other hand, safety motivation does not have a significant effect on violation behaviour, (β = -0.07) even though safety culture directly influences violation behaviour. Consequently, safety motivation mediated the relationship between safety culture and error behaviour but did not mediate the relationship between safety culture and violation behaviour.

Tables 3 and 4 shows the parameter estimates for the initial and revised safety culture structural model. Table 4 shows the results of the mediating effect of safety motivation between safety culture and error behaviour was not significant at the 0.05 level (β = -0.015). However, the indirect effect of safety culture on error behaviour using the mediating influence of safety motivation was significant at the 0.05 level (β = 0.064). Consequently, safety motivation mediated the relationship between safety culture and personnel error behaviour. Contrarily, the indirect effect of safety culture on violation behaviour using the mediating influence of safety motivation was not significant at the 0.05 level (β = -0.012). Therefore, safety motivation did not mediate the relationship between safety culture and violation behaviour.

Table 3
parameter estimates for initial safety culture structural model

Variables	Estimate	S.E.	C.R.	p
Safety Motivation ← Safety Training Frequency	0.034	0.038	0.865	0.369
Safety Motivation ← Education	0.035	0.035	0.972	0.317
Safety Motivation ← Nationality	-0.017	0.012	-1.258	0.194
Safety Motivation ← Position	0.026	0.022	1.084	0.259
Safety Motivation ← Age	0.084	0.020	3.728	***
Safety Motivation ← Safety Culture	0.176	0.044	3.914	***
Error Behavior ← Safety Training Frequency	-0.63	0.043	-1.458	0.137
Error Behavior ← Education	0.029	0.038	0.762	0.429
Error Behavior ← Nationality	0.030	0.015	1.968	0.048
Error Behavior ← Position	0.004	0.025	0.179	0.843
Error Behavior ← Age	0.048	0.024	1.792	0.055
Error Behavior ← Safety Culture	-0.017	0.049	-0.378	0.689
Error Behavior ← Safety Motivation	0.498	0.050	9.526	***
Violation Behavior ← Safety Training Frequency	-0.029	0.036	-0.892	0.369
Violation Behavior ← Education	0.065	0.033	1.952	0.049
Violation Behavior ← Nationality	-0.030	0.012	-2.293	0.019
Violation Behavior ← Position	0.004	0.022	0.218	0.816
Violation Behavior ← Age	-0.085	0.021	-4.087	***
Violation Behavior ← Safety Culture	-0.289	0.037	-6.593	***
Violation Behavior ← Safety Motivation	-0.062	0.044	-1.518	0.118

Table 4
parameter estimates for revised safety culture structural model

Variables	Estimate	S.E.	C.R.	P
Safety Motivation ← Age	0.087	0.021	3.628	***
Safety Motivation ← Safety Culture	0.179	0.045	3.982	***
Error Behavior ← Nationality	0.032	0.015	2.081	0.033
Error Behavior ← Age	0.017	0.026	0.649	0.501
Error Behavior ← Safety Culture	-0.015	0.052	-0.287	0.756
Error Behavior ← Safety Motivation	0.507	0.051	9.683	***
Violation Behavior ← Education	0.062	0.032	1.896	0.052
Violation Behavior ← Nationality	-0.031	0.011	-2.358	0.017
Violation Behavior ← Age	-0.117	0.021	-5.452	***
Violation Behavior ← Safety Culture	-0.294	0.041	-6.976	***
Violation Behavior ← Safety Motivation	-0.067	0.043	-1.547	0.109

*** P value is significant at 0.005 level

Table 5 gives the results of the effect of the three demographic variables. Age is a control variable that had a direct positive significant effect on safety motivation (β = 0.09) and a negative significant effect on violation behaviour (β = -0.12) at the 0.05 level. The negative significance of the coefficient illustrates that when age increases violations decrease or vice versa. Age also had a significant indirect effect on error behaviour (β = 0.032) at the 0.05 level. Education did not have a significant effect on violation behaviour; therefore, for further enhancement of safety performance future research could focus on the importance of education in oil/gas worksites. Lastly, nationality had a

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significant direct effect on error behaviour (β = 0.032) and a direct negative significant effect on violation behaviour (β = -0.031) at the 0.05 level. This result suggests that nationality have a direct effect on safety performance that includes error and violation behaviours, which could be the focus of future research as well.

Table 5: Direct, Indirect, And Total Effect Of The Dependent Variables On The Independent Variables

Independent Variable	Effect Type	Dependent Variable	
		Error Behavior	Violation Behavior
Safety Culture	Direct	-0.015	-0.294
	Indirect	0.064	-0.012
	Total	0.049	-0.306
Safety Motivation	Direct	0.507	-0.067
	Indirect	-0.005	0
	Total	0.502	-0.067
Age	Direct	0.017	-0.117
	Indirect	0.032	-0.005
	Total	0.049	-0.122
Education	Direct	0	0.062
	Indirect	0.005	0
	Total	0.005	0.062
Nationality	Direct	0.032	-0.031
	Indirect	-0.002	0
	Total	0.03	-0.031

Hypotheses Testing and Results: The last step in the SEM technique involved testing the final safety culture structural model (Fig. 6) against the five research hypotheses, see Figure 7 for the results.

	Hypotheses	Decision rule/ results
H1:	*Safety culture has a significant impact on workers safety motivation in the oil/gas work sites.*	**Supported (β=0.18)**
H2:	*Safety culture has a significant impact on workers errors behaviors in the oil/gas work sites.*	**Not supported (β= -0.015)**
H3:	*Safety culture has a significant impact on workers attitude toward violations in the oil/gas work sites.*	**Supported (β= -0.29)**
H4:	*Workers safety motivation has a significant effect on the relationship between the safety culture and error behavior in the oil/gas sites.*	**Supported (β= 0.507)**
H5:	*Workers safety motivation has a significant the relationship between the safety culture and violation behavior in the oil/gas sites.*	**Not supported (β= -0.067)**

Fig. 7. Results of Hypotheses Testing

IV. FINDINGS AND DISCUSSION

SEM Results

1) Even though the study results do not support H2 that the direct effect of safety culture on error behaviour was insignificant, the mediating effect suggests the effect of safety culture on error behaviour through safety motivation.

2) Results of this study support H3 that safety culture has a significant negative direct effect on violation behaviour (β = -0.29). This negative coefficient implies that as the workers awareness of safety culture increases their violations decreases; meaning they are less likely to commit violations or vice versa.

3) The results support H4 because safety motivation mediated the relationship between safety culture and error behaviour. In fact, the mediation exists only if the mediator variable has a significant effect on the dependent variable.

4) Results of this study do not support H5. Safety motivation did not mediate the relationship between safety culture and violation behaviour. Rather, at the 0.05 level, safety motivation had a significant direct effect on violation behaviour (β= -0.067). Therefore, we cannot use safety motivation as a mediator variable between safety culture and violation behaviour. However, safety motivation effectively mediated the relationship between safety culture and error behaviour; but does not mediate the relationship between safety culture and violation behaviour. This is because safety motivation had a direct effect on error behavior, and did not have a direct effect on violation behaviour.

5) The positive impact of safety culture on management commitment, management support, and workers motivation through awards aligns with the findings of [21] and [22]. These findings imply that these three factors have an influence on the safety performance in oil/gas multinational companies. Therefore, management should assume the

larger role by committing to safety in terms of reinforcing and supporting existing initiatives. If none is in place, plans should be to implement such initiatives.

6) Findings also show both management commitment and safety management system can enhance workers safety motivation through accommodating workers concerns, empowering accountability through safety-related decision-making, and commitment. Mohamed (2002) [19] used workers in 10 Australian construction companies revealed that safety climate had a positive influence on the supportive environment of management monitoring, workers participation, which is similar to safety motivation. Several studies evaluated safety climate factors and concluded that safety culture had a significant impact on employee safety motivation and empowerment [6], [13], [16], and [22].

7) Findings also confirmed that safety culture has a significant direct effect on workers' violation behaviour. These results indicate an excellent safety culture awareness toward violations tend to decrease. Findings also support that safety culture directly influences workers violation behaviour in Saudi Arabian oil/gas industry.

8) The significant positive effect of safety culture on safety motivation emphasizes the safety culture role as a predictor of safety motivation. Meaning the oil/gas workers will benefit from more incentives and /or initiatives geared towards raising awareness of the importance safety.

9) Safety culture did not have a significant direct effect on error behaviour, so workers safety awareness of the safety culture in Saudi Arabia does not affect error behaviour. Fogarty, and Shaw (2010) [8] also investigated the influence of safety climate on error behaviour and concluded that error behaviour could not be explained through safety climate directly, which supports the results of this research. Hence, safety culture is not a sufficient factor to predict error behaviour.

10) The insignificance of safety motivation on violation behaviour stresses the importance of safety culture to eliminate violation behaviours. Consequently, emphasizing safety culture is necessary to reduce violations by not only increasing employees' motivation but also creating a robust safety culture.

11) Interestingly, education affected violation behaviour directly and error behaviour indirectly. Education did not have a significant effect on violation behaviour; therefore, for further enhancement of safety performance future research can focus on the importance of education. Nationality directly affected both on safety measures but indirectly affected error behaviour.

V. LIMITATIONS AND CONCLUSIONS

One limitation of this research was validating the error behaviour indicators due to the small number of indicators. This meant that only a certain number of variables could be removed from the model.

Several salient conclusions can be drawn from the findings of this research. The main outcomes are as follows.

This research study used an engineering approach to develop and validate SCAM. SCAM confirmed the following outcomes for Saudi Arabian oil/gas industry and multinational companies:

1. Safety culture does improve safety motivation in the Saudi Arabia oil/gas industry.
2. Safety culture has an influence on decreasing violation behaviours. Workers safety awareness of the safety culture in Saudi Arabia does not affect error behaviour.
3. There is an inverse relationship between age violations. When one increases so does the other decrease or vice versa. Age also effects error behaviour.
4. Interestingly, nationality also has an effect on safety performance that includes error and violation behaviours.

Finally, SCAM can be used to enhance safety culture improvements in high-risk hazardous multinational companies such as oil/gas in Saudi Arabia.

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