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STRUCTURAL EQUATION MODELING ANALYSIS USING SMART PLS TO ASSESS THE OCCUPATIONAL HEALTH AND SAFETY (OHS) FACTORS ON WORKERS' BEHAVIOR

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ABSTRACT

Purpose: The study aims to examine and evaluate the impact of five Occupational Health and Safety (OHS) factors, i.e., Commitment of management, Communication, Training & Education, Health Care and Policies in predicting construction workers' behavior in construction projects of Oman.

Design/methodology/approach: A questionnaire was designed, and data was collectedon arandom sampling basis. Two hundred and fifty-two samples were collected, and the data was analyzed using Smart PLS -Structural Equation Modeling (SEM) technique.

Findings: The study shows thatCommitment of management, Communication, and Training &Educationplays a pivotal role in inspiring the construction workers to improve their perception towards Health and Safety behavior. These factors help in theclear-cut understanding of safety issues and aid in skills development and increase capabilities. All the factors influence the sustainable positive OHS results.

Research limitations/Implications: The present study covers only the construction workers. Entire stakeholders involved in construction project (contractors, clients, and consultants) can be included for further studies.

Social Implications: The study will help to improve the Health and Safety practices in the construction industry and expected to bring in more awareness among workers, which will inevitably bring in a culture of safe behavior. The ultimate result will be a substantial reduction or elimination in safety-related incidents, which helps all the stakeholders (Contractors, Clients and Consultants).

Originality/Value: Only a very few have examined the impact of Occupational Health and Safety factors on the workers' behavior, and usage of Smart PLS is a novel idea, and it is a first-hand study of its kind.

Keywords–*Construction, Occupational Health and Safety, Workers behavior, Smart PLS.*

INTRODUCTION

Occupational health and safety (OHS) problems become thought provoking in the construction projects due to the energetic environment of projects, the contribution of numerous stockholders, and the existence of a great number of unskilled labors. The upgrading of safety standards in construction industries is still not satisfactory despite the continuous attention and determined efforts (Kim et al., 2013). For instance, in the year 2015, the fatal work injury rate of construction projects in the US was 10.1per 100,000 full-time equivalent workers (U.S. Bureau of Labor Statistics, 2015). The highest numbers of fatalities (937) were only in construction projects. The risk factors may vary depending on theseriousness of the injury, accident type, the location of industry, type of construction industry, its size and volume, climatic conditions, the status of Personal Protective Equipment(PPE), etc. (Hecker and Goldenhar, 2013; Wamuziri, 2008).

Major causes of accidents identified in construction industry are due to inadequate experience and inadequate skills of workers, inappropriate selection and use of PPE, disregard for procedures, use of improper tools, tackles and equipment, insufficient safety devices on equipment, working at heights and workers casual approach towards safety (Hamid et al., 2008; Jin and Chen, 2013). Indifferent attitude and lack of discipline by workers are the cause of many accidents at construction sites. The attitude and discipline of workers are influenced by their cultural upbringing, lack of formal education, immaturity, dogged mindset, egoism, jealousy and personal priorities. The above reasons may lead an individual to feel difficult to integrate into a group, causing confusion and misapprehension, which results in accidents. The long-term strategy is required to develop efficient intermediations to reduce accidents and gravity of injury inflicted on construction workers (Puerto and Gilkey, 2014).As a part of the strategy, the Management and contractors need to provide services to give good attention to main factors and make spirited efforts to minimize the accidents at the site(Lee and Jaafar., 2012; Sawacha,

1999). A lot of importance is being given in studies and investigations to the less risky behavior of workers in construction industries. Many steps and initiatives are taken to minimize workers' unsafe behavior.

BACKGROUND

The focus has been to set rules and regulations by formulating organizational health and safety policies. Initiatives are undertaken to upgrade procedures and policies in a proactive way, spread awareness, to empower workers with proper information and knowledge, which can help them to contribute to accident reduction (Lay et al., 2017). The main factor that influences construction safety is the Management commitment. It includes an appraisal of safety responsibility at different levels and effective application of organizational safety policies (Priyadarshani, Karunasena and Jayasuriya, 2013). Several aspects of safety initiatives need to be targeted to attain top-level safety performance, workers participation, management commitment and direct involvement of stakeholders and owners (Hinze, Matthew, and Baud, 2013). Insufficient safety knowledge of project managers may affect safety performance. Though rules and regulations are framed to improve safety and benefit the employees, it may not be helpful due to unenthusiastic behavior, carelessness, and non- adherence to safety procedures.

Construction industries expose the workers to different health hazards; priority should be given to workers' health, which fluctuates from site to site. The management commitment towards health and safety culture is narrated to workers after periodic assessment (Gilkey et al., 2012). Emphasis is laid on improvement in interpersonal relationship and stipulate appropriate support to improve occupational health of employees. Materna et al. (2002) did a study among painting contractors and their workers about lead safety in San Francisco, USA. They found that positive variations can be reached through widespread training and succor in technical know-how. It is vital that workers involved in construction project have at horough understanding of H & S practices, rules & regulations and procedures. A studyby (Lee and Lee, 2015) regarding factors that inspiration pleasure in learning for migratory workers in Kora, found that e-learning founded OHS can be identical actual in increasing the safety consciousness, knowledge and behavior of workers. The invention in learning content, its exactness and dependability can be a good tactic to motivate and promote the learning of workers.Ganah and John (2015) study in the UK for participating building data modeling and health and safety had allowed that daily morning toolbox talk prior to thehurdle of work should be a vital part of effective communication. Nordlof et al. (2015) had a study in steel industries of Sweden on its safety culture and requirement of captivating risks. They found that it is tremendously vital to communicate with workers for safety actions to be operative. Shikdar and Sawaqed (2003) concluded those poor ergonomic skills, inadequate training, and communication distress the worker's output in Oman industries. Lack of possessions also is a factor playing in poor training and damaging ergonomic conditions, which leads to a loss in workers output and poor health and safety in industries from Oman. It is observed that various stakeholders from several construction sectors in Oman are making an attempt to recognize several factors like workers behavior, health care, policies, training & education, management commitment and communication which distress Health and Safety, and interrelationship. There is an increasing awareness towards effective implementation of OHS practices in Oman industries.

RESEARCH METHODOLOGY

A questionnaire was designed, and data was collectedonrandom sampling basis. The questionnaire was sent to two hundred and eighty-nine workers in various construction industries in Oman, out of which two hundred and fifty-two responded. The data was analyzed based on respondent's feedback using Structural equation modeling (SEM) technique using Smart PLS.

Statistical Package for the Social Sciences (SPSS) software was used to find Cronbach's Alpha reliability analysis and factor analysis. Smart PLS approach (Ringle et al., 2015) was used for the measurement model and the structural models to assess instantaneously and to confirm the convergence and discriminate validity of the measure. Reliability of all subfactors in the questionnaire was checked by applying Cronbach's Alpha reliability method. The reliability coefficient value of the questionnaire was found to be high with a result of 0.889 which is higher than 0.7. (Hair et al., 2010).

Smart PLS software was used to confirm the measure of measurement model and structural models. The present study considers the factors such as policies, health care, training & education, the commitmentof management, communication and its impacts on workers' behavior in construction projects. OHS policy factorsweredivided into sub-factors such aswork permit (a7), craft professional (a6), working tools and equipment's (a5), personal protective equipment (a4), financial incentives (a3), moral incentives (a2)and OHS control officers (a1). Subfactors for health care wereregular health check-ups (c7),life insurance (c6), family medical care (c5),family health insurance (c4), worker medical care (c3), health insurance (c2) and medical evaluation (c1). Communication factor was split into subfactors likeemergency exits (e4),signboards (e3),oral communication (e8),emergency call number (e6),incidents information (e2) communication in worker's language (e7),

emergency assembly point (e5) and awareness campaigns (e1).Subfactors for workers' behavior were violated rules (f1), use personal protective equipment's (PPE) (f5),working long hours (f7),follow work procedure (f3), over-confidence (f6), use right tools (f4) and proper posture (f2).Management commitment factor was divided into sub-factors like OHS disciplinary actions (b5), OHS planning (b7),right to refuse (b4), toolbox talk (b2),OHS suggestion collection (b6), staff-regular visit (b1) and OHS rules emphasize (b3). Subfactors for Education and training are OHS induction (d3),OHS orientation program (d2),procedure (d6), Technical (d5), OHS equipment's (d4) and craft certificate (d1)(Silaparasetti, Srinivasarao and Khan, 2017).

Principal component analysis forms the base of PLS and intended for explaining the alteration in constructs elaborate in the model (Chin, 1998). Chin, Marcolin and Newsted (2003) recommended that PLS was an operative analytical tool to decline error.PLS model study comprised of 2 stages. A measurement model was assessed in the first stage and structural model in the second stage. Relations between apparent variables (sub-factors) and latent variables (factors) are measured by measurement model, which was tested from side to side evaluation of validity and reliability of the construct measures in the model. The structural model is shown in figure 1 below. Estimating and examining the path coefficients amongst the constructs test the structural model. Structural model stipulates associations concerning suppressed constructs. Path coefficients are pointers of the model's predictive ability.

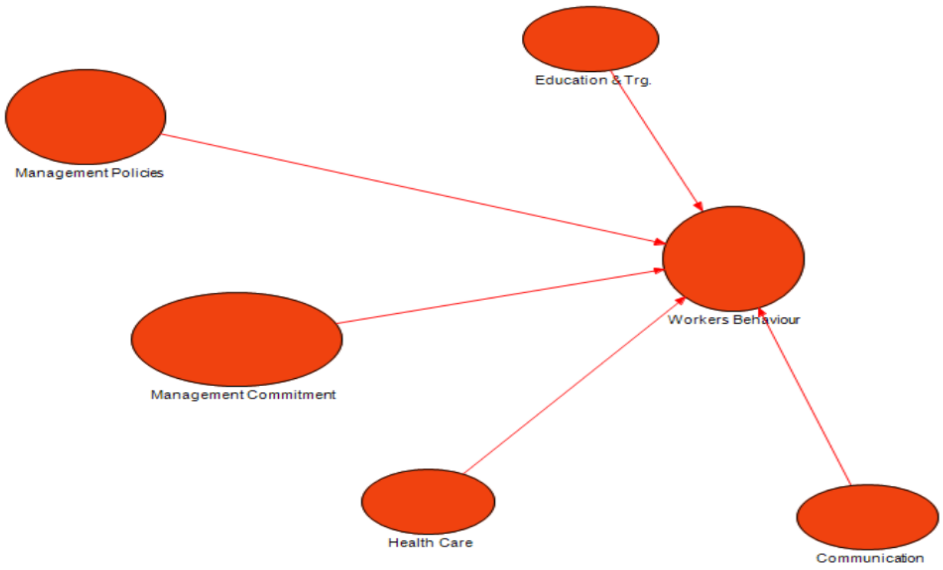

Figure: 1 Structural model

RESULTS AND DISCUSSIONS

Measurement Model

The authors used Smart PLS 2.0.M3 to experiment the model. Tenenhaus et al. (2005) introduced three measures to define the overall quality of the model. First level, Measurement model, second level, Structural model and third level separately structural regression equation used in the structural model. Scale reliability and measuring the separate sub-factors tested in measurement module tracked by the convergent and discriminate validity of construction measures.

The measurement model was tested by measuring the separate sub-factors and scale reliability tracked by the convergent and discriminate validity of constructs' measures. Primarily the associations were displayed among commitment of the management, communication, training & education, policies, health care and workers' behavior. As per Henderson, Sheetz, and Trinkle (2012), validity tests were carried to validate discriminate validity, convergent validity, and the measurement model reliability. Smart PLS algorithm was pragmatic, and the subsequent associations, coefficients, and values of loadings were shown in Initial path model Figure- 2.

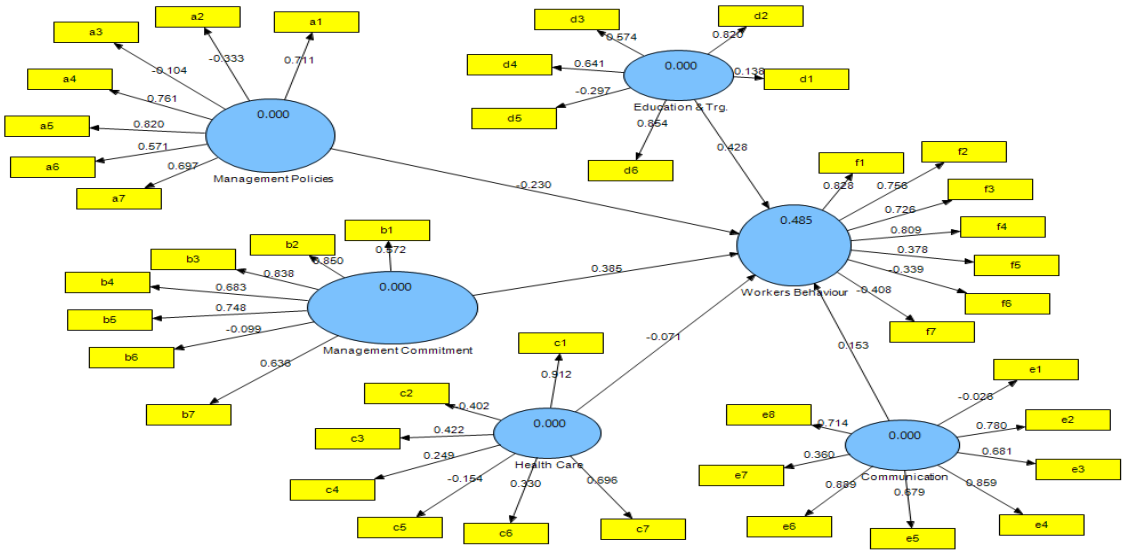

Figure: 2 Initial path model

In the first level, reliability and validity of the measurement module is analyzed and assessed in Smart PLS. To valuation separate sub-factors reliability, the identical factor loadings were evaluated with Smart PLS software. As recommended by Comrey (1973), a value of 0.45 was used as the minimum factor loading for sub-factors. In this study, the subfactors loading measurements of above 0.50 as suggested by Hulland (1999) was accepted. The dimension sub-factors that subsidized smallest to the latent constructs were then detached from the dimension model to improve the model fit. The resultant final path model Figure.3 represents the result after the dropouts, for further investigation.

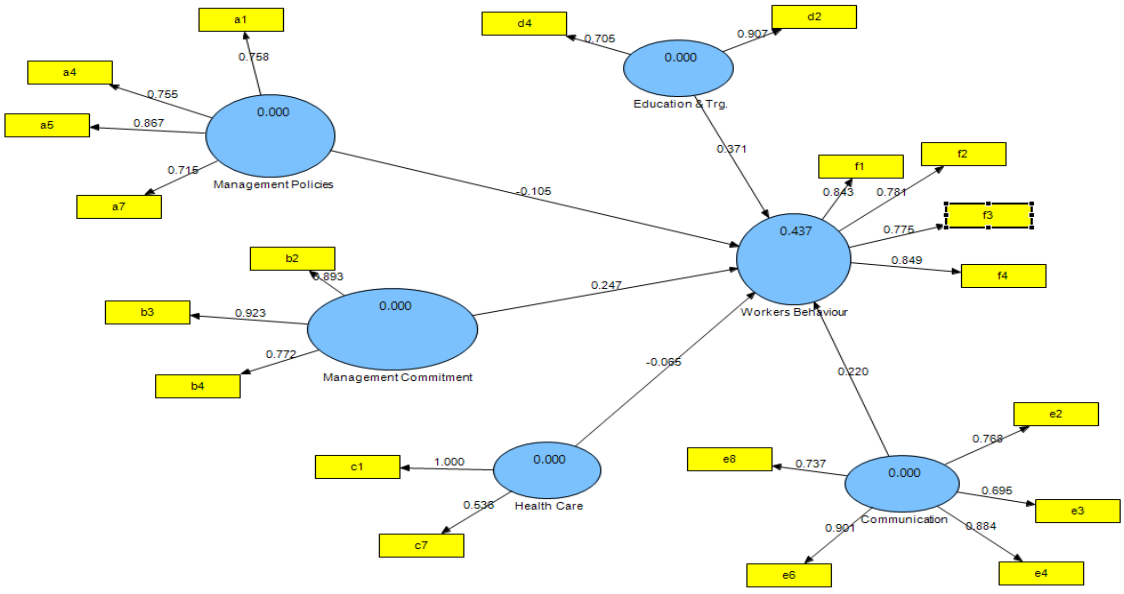

Figure3: Presenting the final path model

Reliability: Inner consistency of measurement model was analyzed by using Cronbach's alpha and composite reliability. Valuation of construct reliability and prediction of inner constancy was focused on composite reliability. As per Hair et al., (2011), in PLS-SEM, composite reliability was more appropriate compared to Cronbach's Alfa since it did not undertake that all indicators were similarly consistent. The cut-off score for composite reliability is 0.7 as suggested by Gefen, Straub and Boudreau (2000) and least score should be above 0.6 for Cronbach's Alfa as suggested by (Hair et al., 2010). The factor

loadings, composite reliability and Cronbach's alpha values intended by PLS algorithms werecharted in Table1.As shown in Table 1, the Cronbach's alpha value is above 0.702,and composite reliability score is more than 0.768. Hence, the model can be said as reliable and trustworthy.

Convergence: Convergent validity of dignified constructs was assessed using Average Variance Extracted (AVE) tests, composite reliability scores and Cronbach's alpha, (Fornell and Larcker, 1981) which were achievedusing Smart PLS software, and the consequences are stated in Table 1. The consequences display that Litwin (1995), which validates that the dimension sub-factor was suitable for their individual constructs, above the 0.7 thresholds propose all of the considered Cronbach's alpha standards and composite reliability scores. Also, as per Fornell and Larcker, (1981) AVE actions the amount of variance that a construct detentions from its displays comparative to the amount due to dimension errors. The consequences of the AVE test Table 1 confirmation that the AVE scores constructs are greater than 0.602.

Table 1: Factor loading for indicators of latent constructs

	Factors and Sub- factors	Factor loading	Cronbach's alpha	Composite reliability	AVE
A	**Organizational health and safety policies**		0.778	0.857	0.602
a1	OHS control officers	0.758			
a4	Personal Protective Equipment's	0.755			
a5	working tools and equipment's	0.867			
a7	work permit	0.715			
B	**Management Commitment**		0.831	0.899	0.749
b2	Toolbox talk	0.893			
b3	OHS rules emphasize	0.923			
b4	Right to refuse	0.772			
C	**Health Care**		0.709	0.768	0.643
c1	Medical evaluation	1			
c7	Regular health check-ups	0.538			
D	**Training & Education**		0.701	0.792	0.660
d2	OHS orientation program	0.907			
d4	OHS equipment's	0.705			
E	**Communication**		0.859	0.899	0.641
e2	Incidents information	0.768			
e3	OHS signboards	0.695			
e4	Emergency exits	0.884			
e6	Emergency call number	0.901			
e8	Oral communication	0.737			
F	**Workers Behaviour**		0.829	0.887	0.660
f1	Violate OHS rules	0.843			
f2	Proper posture	0.781			
f3	Follow work procedure	0.775			
f4	Use right tools	0.849			

Discriminant: As per Hulland (1999), Discriminant validity mentions to the degree to which any single construct is diverse from the additional constructs in the model. In the model, the sub-factors of every construct should be diverse from those of other constructs. The values recorded in Table 2 expressions the diagonal line of standards covering the AVE square root and constructs correlations. Discriminant validity is conventional by confirming that the diagonal line standards are greater related to their columns and rows as endorsed by Fornell and Larcker (1981).

Table 2: Discriminant Validity Results

	Communication	Training & Education	Health Care	Management Commitment	Organizational health and safety policies	Workers Behavior
Communication	1					
Training & Education	0.746	1				
Health Care	0.226	0.277	1			
Management Commitment	0.704	0.562	0.255	1		
Organizational health and safety policies	0.487	0.581	0.418	0.694	1	
Workers Behavior	0.604	0.594	0.106	0.520	0.362	1

Structural Model Analysis

Smart PLS software was used to observe the structural model as confirmed in the research. Path coefficient assessment is included in the structural model indicating the power of the relations among the R-square value, independent variable, and dependent variable. To define the consequence level of the paths definite within the structural model, a bootstrapping re-sampling technique (Efron and Tibshirani, 1993) of two hundred and fifty-two sample was used. A five percent significance level ($p< 0.05$) is used as a statistical conclusion measure. The level of significance using the extent of the identical factor estimates between the constructs is indicated in the resultant t-value. Table 3 briefs the result of the structural model.

Table 3: Path Coefficients along with their bootstrap values and 'T' Values

Factors	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)	Supported	Significance values
Communication -> Workers Behavior	0.220	0.213	0.056	0.056	3.942	Yes	$p< 0.01$ 2.599
Education & Training. -> Workers Behavior	0.370	0.365	0.063	0.063	5.852	Yes	$p< 0.01$ 2.599
Health Care -> Workers Behavior	-0.065	-0.057	0.044	0.044	1.473	No	-----
Management Commitment -> Workers Behavior	0.247	0.248	0.052	0.052	4.705	Yes	$p< 0.01$ 2.599
Organizational health and safety policies -> Workers Behavior	-0.105	-0.113	0.060	0.060	1.756	No	$p< 0.1$ 1.652

The relationship between communication and workers' behavior was supported and significant with the original sample (β) = 0.220, statistics (t) = 3.942 and significant value (p)< 0.01indicates that workers' behavior is influenced directly and positively by communication.

The relationship between training &education and workers' behavior was strongly supported, and significant with the original sample (β) = 0.370, statistics (t) = 5.852 and significant value (p)< 0.01 indicates that workers' behavior is directly influenced by training and education.

The relationship between health care and workers' behavior was not supported and insignificant with β = -0.065 and t = 1.473 indicating that the health care has no much significant with workers' behavior in OHS aspects. It means that the health care does not have the strong impact on workers' behavior. The relationship between management commitment and workers' behavior was 2nd strongest supported and significant with the original sample (β) = 0.247, statistics (t) = 4.705 and significant value (p)<0.01 indicates that the workers' behavior is positively and directly influence by management commitment.

The relationship between policies and workers' behavior was not supported and insignificant with β = -0.104, and t = 1.756indicating that the policies have no much significant influence on the workers' behavior in OHS aspects. It means that the organizational health and safety policies do not have the strong impact on workers' behavior.

The above findings indicate that a unit increase of OHS training and education leads to 0.370 increase in workers' behavior, which is the highest impact, followed by management commitment in which a unit increase led to 0.247 increase in workers' behavior in construction projects and a unit increase in communication for OHS results in 0.220 increase in workers behavior.

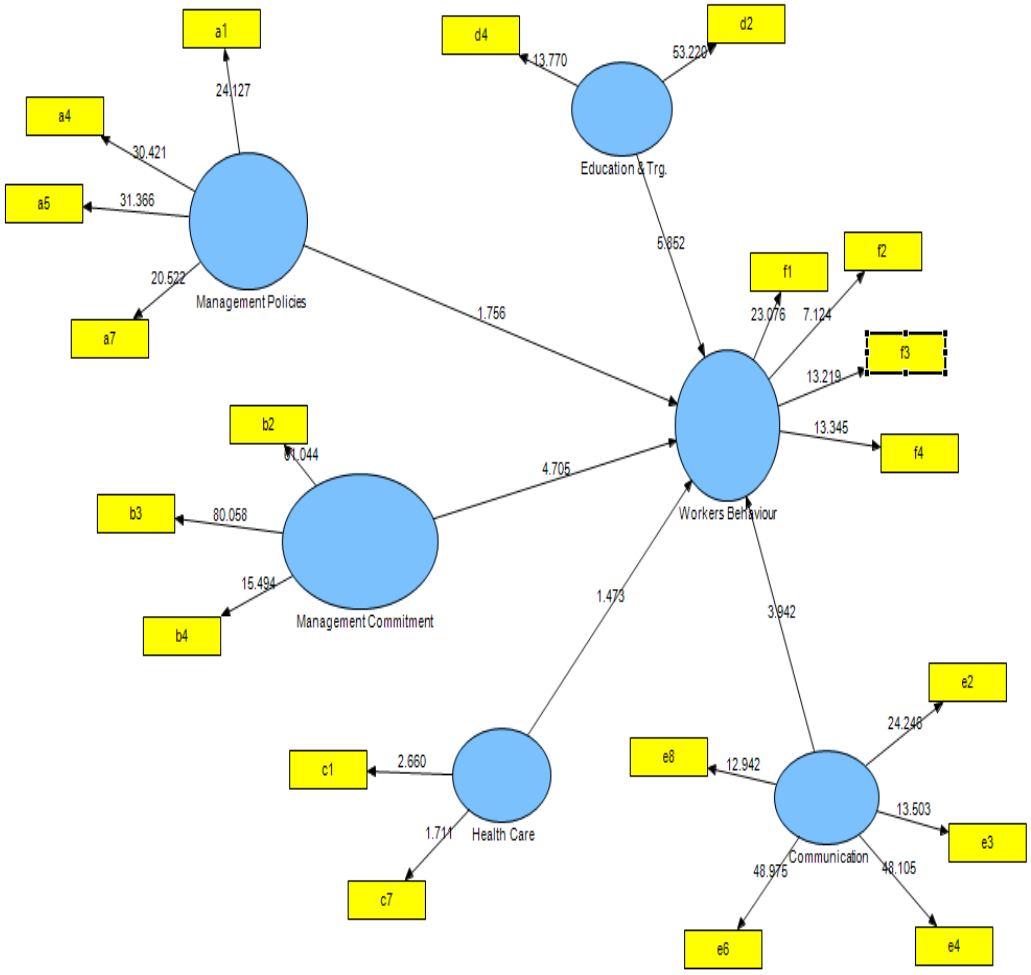

Figure 4: Showing the Bootstrapping Diagram

Assessment of fit

For PLS path modeling, Goodness-of-fit (GoF) is recommended as a worldwide fit measure. In this research, evaluation of PLS path modeling accompanies the goodness-of-fit (GoF) measure.

GoF (0 < GoF < 1) is definite as the geometric mean of the average community/ AVE and average R^2 (for endogenous construct).

$$GoF = \sqrt{\text{average } R^2} * \text{average communality}$$

The GoF value hasbeen calculated for this researchmodel andwas 0.537 (Table 4).The baseline values for validating the PLS model worldwide are GoFlarge = 0.36, GoFsmall = 0.1 and GoFmedium = 0.25 (Akter, D'Ambra and Ray, 2011).

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Table 4: Model Evaluation Results

Factors	R^2	Communality	H^2	Redundancy	F^2
Communication	----	0.642		-----	
Training & Education	----	0.660	.000	-----	.000
Health Care	----	0.643	.000	-----	.000
Management Commitment	----	0.749	.000	-----	.000
Organizational health and safety policies	----	0.601		-----	
Workers Behavior	0.437	0.660		0.142	
Average	0.437	0.659		0.142	
GoF = √**average R^2 x average communality = √ 0.437 x 0.659 = 0.537** (Tenenhaus et al., 2005)					
Note: H^2 = CV – Communality index, F^2 = CV – Redundancy Index					

The q-square statistic is calculated to evaluate the superiority of path model. A Q-square greater than zero wealth the model has predictive significance. The square statistic methods the prognostic significance of the model by repeating the experiential values by the model itself. As per Fornell and Cha(1994) Q-square statistics, a lesser amount of than 0 (zero)mean that the model lacks predictive significance as presented in figure 5.

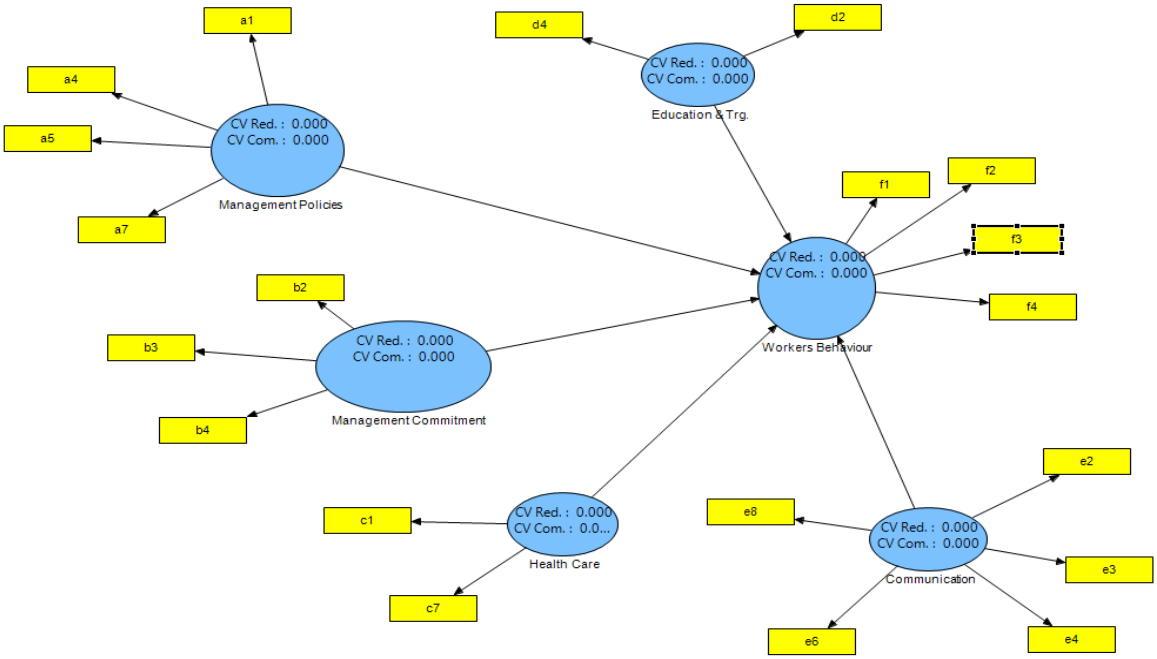

Figure 5: Blind Folding Path Diagram

CONCLUSION AND RECOMMENDATION

Five factors were used to connect the structural model measures out of which three factors supported the hypothesis that training& education, communication, and commitment of management direct positive influence on the workers' behavior. Thisclearly indicates that all three factors (training & education, communication, and commitment of management) had an influence on workers' behavior. However, two factors coefficients between health care and workers' behavior and policies and workers' behavior of workers' behavior do not support the hypothesis. Therefore, it clear shows that the health care and organizational health and safety policies do not have an impact on workers' behavior.

Continuous interaction and communication improves workers' awareness, thus ultimately helping in improvement in workers behavior in industrial construction projects. The management should build a conducive atmosphere which allows the workers

to communicate freely. Some OHS tools like safety suggestion box, reporting of near miss and unsafe conditions can be utilized. Silaparasetti, Srinivasarao, and Khan, (2017) also mentioned that in infrastructure and industrial projects, preference to native language for communication helps in greater awareness among workers.

Regular refresher training to improve skills and qualifications will help to enhance the understanding regarding safety aspects among workers. They have also suggested that in petrochemical construction projects, imparting standard operating procedural (SOP) training regarding plant process may guarantee improved perception and behavior of workers during project execution and plant commissioning. Regular inspections, conducting awareness meetings, incident investigations, reporting procedures should form an important part of management commitment. The recommendation was to conduct daily toolbox talks, suggest workers and encourage them to give feedback would help critically to increase awareness and improve overall behavior of workers in building and utility construction projects.

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